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ASTM BULLETIN

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TESTING MATERIALS

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MAY—1949

No. 158

Sargent Constant Temperature Bath

The 0.01° C. Sargent Constant Temperature Water Bath, which is employed in many laboratories throughout the world where a precise, reliable thermostat is required, is now being supplied with an improved relay unit and heating system. The central heating and circulating unit of the bath is now equipped with three cylindrical heating elements rated at 200, 300 and 400 watts respectively. The 200 watt heater is controlled by the No. 81835 mercurial thermoregulator through a thyratron tube and saturable core reactor in the relay unit. (The use of a saturable core reactor obviates the difficulties commonly encountered with mechanical relaying systems such as pitted contacts, broken moving parts and freezing.) By means of a control mounted on the panel of the relay the output of this heater can be varied from the full 200 watts to approximately 60 watts, thus permitting such adjustment of the heater output that positive overshooting of the regulatory temperature is minimized. With the improved relay system this bath can be adjusted to a precision of ±.005° C. when operating in the vicinity of 25° C.

An autotransformer, adjusted by means of a knob on the relay unit panel, permits the setting of the 300 watt heater so that heat loss from the bath is almost compensated and negative overshoot is reduced to a negligible quantity.

The 400 watt heater may be used to quickly raise the bath temperature to the desired operating level or, in the case where sacrifice of some precision of regulation is of no consequence, to permit operation of the bath at temperatures above 60° C.

In addition, the relay unit is equipped with a master switch, a switch for each heater and a pilot light to indicate that the circuit to the 200 watt heater is closed. Maximum power consumption 1100 watts.

S-84805 WATER BATH—Constant Temperature, 0.01° C., Sargent. Complete with Pyrex jar, 16 inches in diameter and 10 inches in height; central heating and circulating unit; constant level device; cooling coil; No. 81835 thermoregulator and relay unit with cord and plug for connection to standard outlets. For operation from 115 volt 50/60 cycle circuits **$230.00**

S-81991 TUBE—Thyratron, Type 2050. Each ..... **$ 4.00**

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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

TELEPHONE—Rittenhouse 6-5315

R. E. Hess, Editor
R. J. Painter, Associate Editor

CABLE ADDRESS—TESTING

Number 158

May, 1949

Twenty-Two Technical Sessions, Large Number of Committee Meetings Among Features of 52nd Annual Meeting

Strong, Diversified Technical Program, Some 350 Committee Meetings, Other Features, at Atlantic City, Week of June 27

IN ADDITION TO 22 officially numbered technical sessions scheduled for the Society's 52nd (1949) Annual Meeting, Atlantic City, during the week of June 27, there are a number of other informal sessions and round-table discussions which will be of much interest. Some of the technical sessions are being scheduled as very brief sessions designed for the presentation of committee reports. These are scheduled at convenient times with respect to the meetings of these committees. Throughout the entire five days of the meeting scores of the A.S.T.M. technical committees will be in session perfecting and completing work on specifications and tests that has been under way, and initiating new research and standardization work. In addition to the extensive business to be transacted, there is to be a social period on Wednesday evening, June 29, when the hosts for this meeting, the Philadelphia District, are sponsoring an informal program of entertainment.

Another interesting innovation in the program is the official luncheon session scheduled for Tuesday noon when President R. L. Templin will give the annual President's Address, 50-year members will be recognized, and other honors awarded.

A summary of the week's program and full details of all of the sessions are given in the Provisional Program in this BULLETIN, page 8.

Hotel Reservations

Late in April there was distributed to each member and committee member a hotel reservation form which would enable accommodations to be reserved at Chalfonte-Haddon Hall, the headquarters hotel, or the other cooperating Atlantic City hotels. With this form was a Circular Letter that included an advance outline of Annual Meeting sessions and committee meetings, so that a member could plan his trip. *Those who have not returned that hotel form should do so very promptly in order to be assured of a room.*

Committee Meetings

No advance detailed schedule of committee meetings in composite form will be distributed by Headquarters. However, each technical committee secretary presumably will follow the customary plan and advise his members of the meetings scheduled. While the *general* list of committee meetings sent with the Circular Letter was based on the latest information, it should be considered as *tentative* only, and members should look to the schedules from their respective committee secretaries for complete information.

The final program available at the meeting will of course give a list of all meetings and locations.

Preprints of Reports and Papers

To each member in good standing there was mailed early in May a Preprint Request Blank which he could mark and return to A.S.T.M. Headquarters, thus making known his desire to have certain papers or reports that would be preprinted. This material probably will be mailed in three installments, the final one just before or during the Annual Meeting. Members attending the meeting can of course obtain, as they register, copies of preprinted papers and reports, or abstracts of items that it was not possible to preprint. *Preprints will be distributed at Chalfonte-Haddon Hall.*

Luncheon Session, Marburg Lecture, Dinner and Entertainment

Each annual meeting program is in a sense a tailor-made proposition because

the technical features vary from year to year. Consequently, there is very intensive study by the Committee on Papers and Publications and the Staff on what would be the most logical arrangement of the sessions and still provide the necessary dovetailing of committee meetings. Thus, no consistent pattern is developed, although for many meetings the Edgar Marburg Lecture, one of the highlights of the meeting, has been scheduled for late Wednesday afternoon, and frequently the President's Address has been presented as part of a dinner or Wednesday evening session. This year it is somewhat of an innovation to have the Marburg Lecture on "Residual Stresses in Metals" (see later columns for more details) slated for presentation on Tuesday night, June 28, with a special Luncheon Session arranged for the presentation of the President's Address and recognition of long-time members and certain awards.

The exact title of President Templin's address has not been selected by him, but his wealth of experiences and observations in the work of the Society, where he has taken a most active part for many years, and his experience with the testing of materials generally, will be reflected in his address.

Another feature of this Luncheon Session will be the award to the select group of individuals and companies affiliated with the Society for half a century. This will be the first of such awards, and they do focus attention on the Society's long, continuous record of achievement.

Dinner—Entertainment

The Philadelphia District, which includes in its area all of Southern New Jersey as well as Eastern Pennsylvania and Delaware, offered its services to the Board of Directors as general hosts for this meeting, and among the features it plans is an informal dinner on Wednesday, June 29, with no Society business or functions—purely a social period with some outstanding entertainment. The committee also is sponsoring Ladies' Entertainment, and further details of these plans will be made in a direct mailing to the members later in May, but each member is advised that there will be several events planned for his wife and members of his family.

The dinner plans call for an informal cocktail hour preceding the event, then an excellent meal by the hotel, followed by an entertainment program, including music, songs, special dancing, and related acts. The Philadelphia Council in selecting the entertainment features feels that this part of the program can be described as a "don't miss it, or you'll be sorry" kind!

THROUGH PULLMAN CARS TO ATLANTIC CITY

It is again possible to arrange for through cars to Atlantic City. If there are a sufficient number of A.S.T.M. members from a particular area or route to occupy a Pullman car, arrangements can be made over most lines to have this car carried straight through to Atlantic City. Those interested should consult their local ticket agency.

Technical Sessions—Papers and Reports

In addition to the 22 formal technical sessions, there are to be three informal discussions on certain topics, and in several of the committee meetings short informal papers will be presented that are of particular concern to the members of these groups.

There are sessions or round tables at the meetings on the following topics:

Radiography and Ultrasonic Testing
Fatigue of Metals
Soils
Rapid Identifications of Metals (two sessions)
Non-Ferrous Metals—Corrosion, Fatigue, etc.
Testing Wood Poles
Testing Cast Irons with SR-4 Type of Gage (two sessions)
Steel, Ferro Alloys
Fuels, Electrical Insulating Materials, Quality Control, Textiles, Adhesives, Plastics (two sessions), Sandwich Construction
Evaluation Tests for Stainless Steels (two sessions)
Paint, Naval Stores, Wood, Appearance
Accelerated Testing of Bituminous Materials (two sessions)
Concrete, Thermal Insulating Materials
Water-Borne Wastes
Cementitious Materials

All told, there will be over 100 technical papers or formal or informal discussions, most of which will be preprinted or later included in the *Proceedings* or in Special Technical Publications.

Radiography and Ultrasonic Testing:

Two series of papers have been arranged by Committee E-7 on Non-Destructive Testing, the first group Monday afternoon, June 27, relating to radiography, and the second group, Tuesday afternoon, on the subject of ultrasonic testing. Members of the committee and others will participate in these subjects that are of continuing interest. A number of new developments will be touched on and an opportunity given for informal discussion from the floor. There are six papers scheduled on radiography, including such topics as X-ray moving pictures, radium exposure calculator, and others. Five technical men who have considerable experience in the principles and use of ultrasonics will cover such topics as basic principles of practical ultrasonic testing, uses in the forging industry, railroad field, non-ferrous metals field, and in the consumer's plant.

Provisional Program

A Study of the Provisional Program beginning on page 8 of this Bulletin is the best means for members to get a clear conception of just what sessions are planned and when. Synopses of the papers are provided and there are general statements on some of the symposiums. The final program available at the A.S.T.M. registration desk at Chalfonte-Haddon Hall will contain the final details of the sessions, and include a complete schedule of all committee meetings, and give data on entertainment. Members will get the final program as they register.

Fatigue of Metals:

This first official session on Monday evening has six formal papers scheduled on fatigue. While there have been numerous contributions on the subject both before the Society and at other meetings, this phenomenon in metals is one where much research work is under way constantly, and new concepts and new data continue to make the subject one of current interest and concern.

Soils:

In addition to the three contributions on the subject of soils involving the significance of chemical and mineralogical tests, studies of granular materials and model tests of gravel base courses, and geophysical procedures, there is to be reported a study on mechanical oscillators.

Rapid Identification of Metals:

This two-session symposium on methods for rapidly identifying metals is sponsored by A.S.T.M. Committee E-3 on Chemical Analysis of Metals. There are ten papers and discussions scheduled by active men in the field, with rather comprehensive coverage. Some of the topics relate to the outlook of spot test analysis, electrography, instrumental methods and specific discussion of work on ferrous metals and alloys.

Non-Ferrous Metals:

While several sessions will be of distinct interest to the non-ferrous field, one has been titled "non-ferrous" because of several committee reports and the nature of the papers included, covering among other subjects the corrosion behavior of aluminum alloys, studies of aluminum alloy sheet, vibration and creep of lead, and others.

Testing Wood Poles:

This subject is currently receiving intensive consideration in A.S.T.M. Committee D-7 on Wood and specifically its Subcommittee VII on Wood Poles and Cross Arms. The committee has prepared test methods for making tests of full-sized poles which provide for two procedures—a crib method and a machine method. Breaking strength tests are important because of the necessity of establishing allowable fiber stresses and this whole program will be reviewed at the round-table discussion at the A.S.T.M. meeting on Wednesday morning, June 29.

Evaluation Tests for Stainless Steels:

Arranged by Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, this eleven-paper symposium will give an up-to-date picture of our latest knowledge and practice. Some of the subjects covered include a review of our present knowledge of low-carbon 18–8 stainless steel, accelerated tests on weldments, an appraisal of methods used for evaluating corrosion resistance, influence of carbon and molybdenum on intergranular corrosion resistance with and without columbium, studies in various acids, plant tests of welded materials, and others.

Testing Cast Iron with Strain Gages:

The use of SR-4 types of strain gage in testing and evaluating cast iron will be covered in a number of papers forming the two-session symposium on Wednesday morning and afternoon of the meeting. Arranged by Committee A-3 on Cast Iron, the symposium has some 15 papers scheduled. A wide variety of uses of the strain gage on various cast products will be covered in detail.

Accelerated Testing of Bituminous Materials:

The importance of accelerated tests of bituminous materials is evident from the interest in the symposium arranged under the joint auspices of Committee D-4 on Road and Paving Materials, and D-8 on Bituminous Waterproofing and Roofing Materials. The two sessions involved are scheduled for Thursday afternoon, June 30, and Friday morning, July 1, respectively, with about seven papers in each. It will be noted that topics to be covered relate to laboratory heat tests, road tars, bituminous concrete, use of an abrasion test, and a review of accelerated methods for road tars. Also discussed will be durability of roofing asphalts, use of mineral stabilizers, effect of ultraviolet light and water upon pitches, and a word of caution on durability tests.

Steel, Plastics, Concrete and Cementitious Materials, and Others:

The session on steel on Wednesday will have reports and papers involving properties of low-carbon N155 alloy at room temperature and 1200 F., the others involving the effects of temperature on material structure and manufacturing practices of various properties of medium and low-carbon steel.

The sixteenth session on plastics, in addition to the Report of Committee D-20, has discussions on impact and flexural testing, with creep tests and creep characteristics the subject of three separate papers. Damping and resonant load-carrying capacities of polystyrene and other high polymers also will be described.

In the cement, concrete, and aggregates field there are numerous items—one, a test for predicting cement-aggregate reaction, another, the engineering properties of coral reef materials, and one on concrete for airport runways, and long-time tests of concrete with different cements.

Standards for Water-Borne Wastes:

Intensive interest in the subject of proper standards for analyzing water-borne industrial wastes is indicated not only by the round-table discussion to be held Thursday, June 30, under the auspices of Committee D-19 on Industrial Water, but the intense interest in the new subcommittee on this subject. Forming the basis of the discussion are papers dealing with the need for standards, descriptions of measurements and sampling wastes, and discussion on the analysis of water-borne wastes.

1949 Marburg Lecture on Residual Stresses in Metals

Dr. William Marsh Baldwin, Jr., Research Professor and Director, Metals Research Laboratory, Department of Metallurgical Engineering, Case Institute of Technology, Cleveland, Ohio, will deliver the 1949 Marburg Lecture on the subject "Residual Stresses in Metals." The Lecture Committee felt that this subject was extremely timely, and with considerable work being carried out under both company and Government auspices, a comprehensive discussion would be interesting and profitable.

A short statement on the basic points to be covered in the Lecture follows:

The lecture will discuss how residual stresses are developed in metals. The fundamental differences in the mechanisms by which residual stresses are developed by cold working operations such as rolling, drawing, extrusion, etc.; by heat treatment, and by casting and welding, will be described. A description of the experimental methods used to evaluate residual stresses will be given; the various residual stress patterns found in fabrication of metals will be detailed; a discussion of the effects of residual stresses will be made; and, lastly, methods for the elimination of residual stresses will be discussed.

About the Lecturer:

A native of Buffalo, N. Y., Dr. Baldwin was graduated from Rensselaer Polytechnic Institute in 1936 with a degree of Ch.E. and continued his studies at the University of Munich in Germany, Federal Polytechnic Institute in Zurich, Switzerland, and Case Institute of Technology, Cleveland, Ohio, receiving his M.S. in 1941, and his Ph.D. in 1945 from the latter school.

From 1938 to 1948 he was associated with the Chase Brass and Copper Co., Inc., Cleveland, Ohio, as Metallurgical Engineer. In July of 1948 he became Research Professor and Director of the Metals Research Laboratory of the Department of Metallurgical Engineering at Case Institute of Technology.

He is a member of the American Institute of Mining and Metallurgical Engineers, American Society for Metals, and the Society for Experimental Stress Analysis. He is the author of a number of technical articles, one of which earned him the annual award in 1945 of the A.I.M.E. Institute of Metals Division.

W. M. Baldwin, Jr.

This Program is Subject to Change

All time indicated is Eastern Daylight Saving Time

Provisional Program

FIFTY-SECOND ANNUAL MEETING

of the

AMERICAN SOCIETY FOR TESTING MATERIALS

ATLANTIC CITY, N. J. **JUNE 27 to JULY 1, 1949**

Committee Meetings held throughout the week at Chalfonte-Haddon Hall

MONDAY, June 27	TUESDAY, June 28	WEDNESDAY, June 29	THURSDAY, June 30	FRIDAY, July 1
		Morning		
Committee Meetings only	*2nd* Session of Soils (Report D-18) *3rd* Symposium on Spot Test *4th* Luncheon Session—President's Address, Recognition of 50-Year Members, Introduction of New Officers.	*7th* Session on Non-Ferrous Metals—Corrosion, Fatigue, etc. (Report B-3, B-4, B-7, B-8, E-7, E-9) Round-Table Discussion on Wood Pole Testing *8th* Symposium on Testing Cast Irons with SR-4 Type of Gage (Report A-3)	*12th* Symposium on Evaluation Tests for Stainless Steels (Report A-10) *13th* Report Sessions (Reports B-1, B-2, B-5, B-6, B-9, E-2) *14th* Session on Paint, Naval Stores, Wood, Appearance (Reports D-1, D-7, D-17, E-6, E-12)	*20th* Symposium on Accelerated Durability Testing of Bituminous Materials (Cont.)
		Afternoon		
Papers on Radiography	*5th* Symposium on Spot Test (Cont.) (Report E-3) Papers on Ultrasonic Testing	*9th* Symposium on Testing Cast Irons with SR-4 Type of Gage (Cont.) (Report E-1) *10th* Session on Steel, Ferro Alloys (Reports A-1, A-5, A-7, A-9, E-4, Jt. Effect of Temp.) *11th* Session on Fuels, Electrical Insulating Materials, Quality Control, Textiles, Adhesives, Plastics, (Reports C-19, D-3, D-5, D-9, D-12, D-13, D-14, E-11)	*15th* Symposium on Evaluation Tests for Stainless Steels (Cont.) (Report A-6) *16th* Session on Plastics (Report D-20) *17th* Symposium on Accelerated Durability Testing of Bituminous Materials (Reports D-4, D-8)	*21st* Report Session (Reports D-2, D-6, D-10, D-11, D-15, D-16) *22nd* Session on Cementitious and Building Materials (Reports C-1, C-2, C-8, C-12, C-15, C-17, C-18)
		Evening		
1st Opening Session—Fatigue of Metals	*6th* Marburg Lecture on Residual Stresses in Metals by W. M. Baldwin, Jr.; Medal Awards	Cocktail Party and Annual Dinner Entertainment	*18th* Session on Concrete, Thermal Insulating Materials (Reports C-7, C-9, C-16) *19th* Round-Table Discussion on Standards for Water-Borne Waste (Report D-19)	

PAPERS ON RADIOGRAPHY—Monday, June 27, 1.30 p.m.

Committee E-7 on Non-Destructive Testing will hold a papers session on Radiography at the Annual Meeting at Atlantic City at which time six papers on late developments in this field will be presented. The papers are as follows:

X-ray Moving Pictures. C. M. Slack, Westinghouse Electric Corporation.
Recent Progress in High Speed Flash Radiography. J. C. Clark, Los Alamos Scientific Laboratory.
Initial Experience with the First Industrial Type Mobile Betatron. D. T. O'Connor, Naval Ordnance Laboratory.
Mobilizing the Van de Graaf Generator for Precision Radiography. E. A. Burrill, High Voltage Engineering Corporation.
Radium Exposure Calculator. N. A. Kahn, New York Naval Shipyard.
Screen Penetrameters. . H. H. Lester, Watertown Arsenal.

Monday, June 27 8 p.m. First Session

Opening Session

Fatigue of Metals

Formal Opening of the Fifty-second Annual Meeting. President R. L. TEMPLIN.

Approval of Minutes of 1948 Annual Meeting.

Annual Report of the Board of Directors. C. L. WARWICK, Executive Secretary

The Influence of Fluctuations in Stress Amplitude on the Fatigue of Metals. T. J. Dolan, F. E. Richart, Jr. and C. E. Work, University of Illinois.

An investigation was made to determine the relative significance of repeated stress on total fatigue life when the stress history was made up of fatigue stresses at various levels. Throughout the life of each specimen the amplitude of stress was varied at regular intervals (either gradually or abruptly) between two predetermined values. Tests conducted on five different metals indicated that the fatigue life was not directly related to the cycle ratios of the stresses applied at each stress level, but there existed a rather complex relationship between total fatigue life and the magnitudes of both the upper and lower stress amplitude. Under certain conditions, repetitions of a stress below the ordinary fatigue limit decreased the fatigue life, but under other test conditions increased the fatigue life. Comparisons are made of certain behavior patterns with the increased life commonly developed by "coaxing," that is periodically increasing the repeated stress by small increments.

The Effects of Spray Metallizing Procedures on the Fatigue of Steel. W. Lee Williams, U. S. Naval Engineering Experiment Station.

This paper presents results of tests to determine the effects of spray metallizing and attendant methods of surface preparation on the flexural and torsional fatigue properties of steel. The four conventional methods of surface roughening (electric bonding, grit blasting, rough threading and grooving, and knurling) have been investigated. The use of shot peening in conjunction with electric bonding has been covered. An analysis has been made to show the principal reasons for the observed reductions in fatigue strength and the way in which these are related to the size of the tested section.

Dynamic Creep and Rupture Properties of Temperature Resistant Materials Under Tensile Fatigue Loading. B. J. Lazan, Syracuse University.

The limitations of static testing and the importance of dynamic creep and rupture properties in design for high-temperature service are discussed. Newly developed dynamic testing machines and measuring equipment for determining creep and rupture properties are described. Data on several temperature resistant materials are presented, to show the influence on dynamic creep and time to rupture of various combinations of superimposing alternating stress and tensile preload. The increased creep and rupture resistance of some materials subjected to cyclic stress is discussed in terms of possible metallurgical changes caused by cyclic stress. Data are present to show the greatly decreased ductility the superposition of cyclic stress on tensile preload.

Effect of Pulsating Loads on the Deep Characteristics of Aluminum Alloy 14 S-T. M. J. Manjoine, Westinghouse Electric Corp.

The parts of machines operating at elevated temperatures are often subjected to oscillating and steady stresses. These parts are designed by assuming that one of these stresses is the dominate one or that the stresses may be combined in some manner.

This paper described a creep-rupture machine in which oscillating and steady loads may be applied. This machine was developed during the war to check the influence of adding a small oscillating stress to the steady stress in a creep-rupture test. The steady load is applied through a spring and the oscillating load is produced by a rotating eccentric. Both loads are combined by utilizing a special lever arm. An autographic creep curve is recorded.

The results of tests at 400 F. on specimens from a 14S-T disk are presented to illustrate a manner in which the oscillating and steady stresses may be combined.

A New High Speed Sheet Metal Fatigue Testing Machine for Unsymmetrical Bending Studies. G. R. Gohn and E. R. Morton, Bell Telephone Laboratories, Inc.

A constant deflection fatigue machine suitable for testing in bending 24 sheet metal specimens simultaneously at as many as 12 different values of mean stress and at any testing speed up to 3000 rpm. is described. Alternating stresses ranging from zero to a maximum value corresponding to a deflection of one inch may be superimposed upon any mean stress of such magnitude that the total deflection does not exceed 2 in. The specimens are deflected by means of adjustable arms fastened to oscillating rock shafts. These rock shafts are oscillated by means of a variable throw-crank shaft, connecting rods and Pitman arms.

Tuesday, June 28 9 a.m. Second Session

Held Simultaneously with the Third Session

Soils

Report of Committee D-18 on Soils for Engineering Purposes. E. J. Kilcawley, Chairman.

The Procedure and Significance of Chemical and Mineralogical Tests on Soils. T. William Lambe and V. F. B. de Mello, Massachusetts Institute of Technology.

Based on an extensive review of the literature and on laboratory research at the Massachusetts Institute of Technology, the authors have attempted to present in a concise form the significance and procedure of those chemical and mineralogical tests which are important to soil mechanics. The tests described are mineral determination, base-exchange capacity, nature of exchangeable ion, degree of acidity (pH), and tests for admixed chemicals.

Methods of Test of Permeability of Granular Materials and Model Tests of Gravel Base Courses. Ralph Hansen and James F. Haley, Corps of Engineers.

Subsurface Explorations by Geophysical Methods. E. Raymond Shepard, U. S. Corps of Engineers.

The principles of both the seismic and the electrical resistivity methods of subsurface

exploration are described and illustrated. The results of field tests as made by the Corps of Engineers show the methods to be relatively rapid and inexpensive in determining the depth of overburden as well as some of its physical properties. The seismic method has been particularly useful in the study of large dam sites while the electrical resistivity method is more applicable to highway and levee construction. Methods of interpretation and analysis are described. The paper will be illustrated by a number of lantern slides.

Study on Mechanical Oscillators. R. K. Bernhard, Rutgers University.

A mechanical oscillator to excite sinusoidal one and two dimensional vibrations has been developed which allows a continuous change of the resultant force vector in frequency, magnitude, direction, and action line while the oscillator is in operation. Analytical and graphical solutions are presented. The construction of such an oscillator, including an automatic electromechanical control, is described and some fields of applications are discussed.

Tuesday, June 28 10 a.m. Third Session

Held Simultaneously with the Second Session

Symposium on Rapid Methods for the Identification of Metals

In view of the wide usefulness of rapid methods for the identification of metals, this symposium is being held to present discussions of the general principles involved in the various types of methods in current use and also discussion of specific applications of rapid identification methods to particular classes of metals and alloys.

Introductory Remarks. L. A. Wooten, Bell Telephone Laboratories Inc.

Development, Present State, and Outlook on Spot Test Analysis. Fritz Feigl, Laboratorio da Producao Mineral, Ministerio da Agricultura, Argentinia.

Electro Spot Testing and Electrography. H. W. Hermance and H. V. Wadlow, Bell Telephone Laboratories, Inc.

Instrumental Methods for the Rapid Indentification of Metals. R. R. Webster, Jones & Laughlin Steel Corp.

Tuesday, June 28 12.15 p.m. Fourth Session

Luncheon Session—President's Address, Recognition of 50-Year Members and Introduction of New Officers

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Tuesday, June 28 2.30 p.m. Fifth Session

Symposium on Rapid Methods for the Identification of Metals (*Continued*)

Report of Committee E-3 on Chemical Analysis of Metals. D. R. Evans, Chairman.

***Symposium on Rapid Methods for the Identification of Metals* (*Continued*)**

Separating Alloys by Relative Spot Tests. H. Kirtchik, General Electric Co.

Rapid Methods for the Identification of Copper-Base Alloys. R. P. Nevers, American Brass Co.

Rapid Identification of Metal Finishes. D. R. Evans, Western Electric Co.

Examination of Plated and Protective Coatings by Electrographic Analysis. N. Galitzine and S. E. Q. Ashley, General Electric Co.

Separating Tin-Lead, Antimony-Lead, and Pure Lead by Spot Test Analysis. C. A. Ray, Nassau Smelting & Refining Co.

Rapid Tests for the Identification of Alloy Steels. Elbert C. Kirkham, Utah Engineering Experiment Station.

PAPERS ON ULTRASONIC TESTING—Tuesday, June 28, 2:30 p.m.

As a sequel to the round-table discussion on Ultrasonic Testing held in Detroit at the last annual meeting, Committee E-7 on Non-Destructive Testing will hold a discussion on Ultrasonic Testing at Atlantic City. The theme of this discussion will be that ultrasonic testing is being used extensively, is practical, and is an aid to manufacturing processes as well as being an inspection tool. Some of the talks to be presented are as follows:

1. Sperry Products, Inc.—J. C. Smack will discuss "Basic Principles of Practical Ultrasonic Testing."

2. Barium Steel and Forge, Inc.—J. C. Hartley will talk on "Ultrasonics in the Forging Industry" or "Ultrasonics Applied to the Manufacture of Forgings."

3. Aluminum Company of America.—A qualified member of the organization will talk on "Ultrasonics in the Aluminum Industry" or "Ultrasonics in the Non-Ferrous Metals Field."

4. Erie Railroad Company.—E. D. Hall will present "Ultrasonics in the Railroad Industry."

5. Westinghouse Electric Corporation.—D. M. Kelman will talk on "Ultrasonics from the Consumer's Standpoint" or "The Role of Ultrasonic Testing in the Consumer's Plant."

In addition the organizing committee originally planned talks on the following subjects, which are still in a tentative status:

1. "Tricks with Ultrasonics" or "New Developments in the Ultrasonic Testing Field."

2. "Ultrasonic Testing in Ordnance Work."

3. "Ultrasonics in the Basic Steel Industry."

All the speakers are authorities in the field and there will be an open period for discussion of this new non-destructive testing tool.

Tuesday, June 28 8 p.m. Sixth Session

Marburg Lecture, Dudley Medal, and Awards

Marburg Lecture—Residual Stresses in Metals—W. M. Baldwin, Jr., Case Institute of Technology

The purpose of the Edgar Marburg Lecture is to have described at the annual meetings of the Society, by leaders in their respective fields, outstanding developments in the promotion of knowledge of engineering materials. Established as a means of emphasing the importance of the function of the Society of promoting knowledge of materials, the Lecture honors and perpetuates the memory of Edgar Marburg, first Secretary of the Society, who placed its work on a firm foundation and through his development of the technical programs brought wide recognition to the Society as a forum for the discussion of properties and tests of engineering materials.

(See News Article on Lecture, p. 7)

Charles B. Dudley Medal. Award to W. W. Buechner, R. J. Van de Graaf, H. Feshbach, E. A. Burrill, A. Sperduto, and L. R. McIntosh.

Richard L. Templin Award to W. T. Lankford.

Sam Tour Award to V. M. Darsey and W. R. Cavanagh.

Wednesday, June 29 9.30 a.m. Seventh Session

Held Simultaneously with the Eighth Session

Non-Ferrous Metals—Corrosion, Fatigue, etc.

Report of Committee B-4 on Electrical Heating, Resistance, and Related Alloys. S. A. Standing, Chairman.

Report of Committee B-7 on Light Metals and Alloys, Cast and Wrought. I. V. Williams, Chairman.

Creep and Stress-Rupture Investigations on Some Aluminum Alloy Sheet Metals. J. E. Dorn and T. E. Tietz, University of California.

The creep and stress-rupture characteristics of 35 ¼H, 35 H, 535 ¼H, 525 H, 615 T, and 245 T are reported from 90 to 400 F. for times up to 1000 hr. The above sequence of alloys was found to be the order of increasing resistance to creep and stress-rupture. Cold rolling has a beneficial effect on the creep and stress-rupture resistance of the work hardenable alloys over the commercial ranges of cold rolling.

Fatigue Characteristics (Reversed Bending) of Aluminum Alloy 75S-T-T6 Plate as Effected by Type of Machine and Specimen. T. T. Oberg and R. J. Rooney, Air Matériel Command.

In Reference 1 the data were for 75S-T-T 6 material taken from random location in an extrusion. The data in the present paper are based on more numerous tests from a single plate which it is believed would be representative of as nearly homogeneous material as possible throughout and possess metallurgical characteristics similar in nature and history.

Vibratory nonrotating cantilever fatigue tests were made in a Krouse plate fatigue machine (fixed deflection), using test specimens of round, square, and rectangular critical sections. Rotating beam-specimens (round) were tested in an R. R. Moore type rotating beam (constant load) fatigue testing machine. All specimens were machined to a critical thickness or diameter of ½ in. from a 1-in. plate. Fatigue curves were obtained from the various specimen shapes. The round specimens showed the highest fatigue strengths, the nonrotating being higher than the rotating. The square specimen developed higher strength than the rectangular specimens. In general, specimens with the smallest volumes subjected to the nominal peak stress showed the highest fatigue strengths.

Report of Committee B-8 on Electrodeposited Metallic Coatings. C. H. Sample, Chairman.

Report of Committee E-7 on Non-Destructive Testing. J. H. Bly, Chairman.

Report of Committee E-9 on Fatigue. R. E. Peterson, Chairman.

The Influence of Vibration on the Creep of Lead. J. Neill Greenwood, University of Melbourne.

Creep tests on two industrial leads (both very pure) and two lead alloys, one containing 0.027 per cent silver and the other 0.07 per cent copper, have been made under conditions whereby a gentle 50 cycles per sec. vibration was superposed on direct tensile stress. The stresses were between 100 and 350 psi. It is shown that vibration increases the rate of creep and also accelerates the recrystallization under stress. The effect of silver on the over-all creep rate under vibratory conditions is, in general, negligible, though in detail it seems evident that the creep characteristics or the alloy are quite different from those of the basis lead. The effect of copper is affected by the degree of dispersion. Annealing lead at 120 C. (250 F.) for 24 hr. stabilizes the crystal grains in some way, reduces the creep rate under given conditions, and reduces the susceptibility to recrystallization under stress.

Report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. K. G. Compton, Chairman.

Appendix:

Effect of Weather on the Initial Corrosion Rate of Sheet Zinc. O. B. Ellis, Armco Steel Corp.

The weight losses of 26 samples of sheet zinc exposed for periods of 28 days in a mild industrial atmosphere have been studied with relation to weather variations during the exposure periods. A multiple correlation analysis of the data has shown that the variations in weight loss can be correlated with the number of hours the specimens were wet during the first five days of exposure. The time wet after the first five days was of little effect in determining the initial corrosion rate.

ROUND-TABLE DISCUSSION ON WOOD POLE TESTING—Wednesday, June 29, 9:30 a.m.

This round-table discussion is being sponsored by Committee D-7 on Wood in view of its proposed expansion of activities to include the collection of reliable data on the strength of wood poles. This field is of interest to both producers and users of poles because of the persistent difficulty of interpreting test results that have been obtained by varying methods without the benefit of standardized testing procedures. The discussion will review a proposed testing program and discuss methods of its implementation. It is expected that many interested users and producers of poles will be present.

Wednesday, June 29 9.30 a.m. Eighth Session

Held Simultaneously with the Seventh Session

Symposium on Testing Cast Iron with SR-4 Type of Gage

Report of Committee A-3 on Cast Iron. E. R. Young, Chairman.

Symposium on Testing of Cast Iron with SR-4 Type of Gage

Commercial gray iron castings are often designed in complex shapes which may integrate a number of simple geometrical figures into a final form. Plotting the flow of stress in a complex casting under load may become a jigsaw puzzle. One of the most aggravating cases occurs when a surface that should develop a tensional stress actually registers a compressional stress. Stress patterns that are further complicated by the cross-movements of static loads, dynamic loads, and thermal loads, combine to confuse the designer. In early designs, it is common to plan, build, test, and load the job to destruction, then redesign or "beef up" the weakened zones, and finally proceed with casting production.

Because cast iron will break with a nonductile fracture under simple tensile stress, its application has occasionally been avoided in favor of more ductile material which will deform and thus sound a warning, or it will malfunction in a dynamic loading system and thereby give notice of impending failure. Nonductile fractures are known to develop in ductile materials like steel, as in the case of the fatigue failure. Means for exploring the stress distribution in castings have been provided by various means and specifically in the strain-resistance wire gage system.

Stress Analysis of Automotive Cylinder Blocks. Martin A. Erickson, Chrysler Corp.

Residual Stresses in Cylinder Blocks. R. J. King, Caterpillar Tractor Co.

An Analysis of Locked-In Stresses in Automotive Cylinder Blocks. S. J. Stockett and H. W. Lownie, Jr., Battelle Memorial Institute.

Strain Testing of Crank Shafts, Engine Frames, and Cylinders. H. M. Hardy and T. O. Kuivinen, The Cooper-Bessemer Corp.

Strain Gage Tests on Diesel Cylinder Blocks, Heads, and Pistons. C. L. Newton and J. D. Swannack, Fairbanks-Morse Co.

Stress-Strain Tests on Rectangular Cast Iron Beams. Oliver Smalley, Meehanite Metal Corp.

Stress-Strain Tests on Various Cast Iron Beam Sections. H. M. Hardy and T. O. Kuivinen, The Cooper-Bessemer Corp.

Wednesday, June 29 1.30 p.m. Ninth Session

Held Simultaneously with the Tenth and Eleventh Sessions

Symposium on Testing Cast Iron with SR-4 Type of Gage (*Continued*)

Report of Committee E-1 on Methods of Testing. J. R. Townsend, Chairman.

Symposium on Testing of Cast Iron with SR-4 Type of Gage (Continued)

Stress Analysis of a Cast Iron 125-lb. Valve Assembly. V. T. Malcolm and S. Low, Chapman Valve Manufacturing Co.

Stress Analysis of a Cast Iron Split Tapping Sleeve. E. C. Sears, J. W. Miner, and E. D. McCauley, American Cast Iron Pipe Co.

Stress-Strain Analysis of Cast Irons for Valve Parts. Harold Wyatt, Lunkenheimer Co.

Residual Stresses in Cast Iron Deaerating Trays. J. A. Cameron, Elliott Co.

Stress Determination in Cast Irons for Railroad Service. Richard A. Flinn and Robert J. Ely, American Brake Shoe Co.

Some Strain Gage Studies of Cast Iron Punch Press Frames. Given A. Brewer, Massachusetts Air Industries.

Location and Measurement of Stresses in Gray Iron Tractor Castings. Hyman Bornstein, Deere & Co.

Stress-Strain Studies of Cast Iron for Textile Machinery Parts. Victor E. Hillman, Crompton & Knowles Loom Works.

Wednesday, June 29 1.30 p.m. Tenth Session

Held Simultaneously with the Ninth and Eleventh Sessions

Steel, Ferro-Alloys

Report of Committee E-4 on Metallography. L. L. Wyman, Chairman.

Report of Committee A-7 on Malleable-Iron W. A. Kennedy, Chairman.

Report of Committee A-9 on Ferro-Alloys. W. C. Bowden, Jr., Chairman.

The Influence of Conditions of Heat Treatment and Hot-Cold Work on the Properties of Low-Carbon N155 Alloy at Room Temperature and 1200 F. J. W. Freeman, E. E. Reynolds, D. N. Frey, and A. E. White, University of Michigan.

The ranges in properties at room temperature and in the rupture test at 1200 F. are shown for systematic variations of conditions of solution treating, aging, and hot-cold working of one heat of Low-Carbon N 155 bar stock. The over-all range in yield strength for 0.02 per cent offset at room temperature was 30,000 to 134,000 psi.; and the over-all range of rupture strength at 1200 F. was 40,000 to 66,000 psi. for 100 hr. and from 35,000 to 56,000 psi. for 1000 hr. The equivalent rupture time under a stress of 40,000 psi. would be from 100 hr. to an estimated 600,000 hr. for the same stock with different treatments. These ranges are fairly typical of the effects of conditions of treatment of alloys of the same general type.

Report of Committee A-5 on Corrosion of Iron and Steel. T. R. Galloway, Chairman.

Elastic and Fracture Toughness Studies of Stainless Steel. Carl W. Muhlenoruch, Northwestern Technological Institute.

Type 301 stainless steel sheet and rod of several tempers is shown to have great elastic and fracture toughness, the former being defined as the area under the stress-strain diagram at the yield-strength and the latter as the area under the true-stress-true-strain diagram to rupture. The theoretical fracture toughness thus determined is compared with actual values obtained from tension impact tests. It is shown that the elastic toughness of stainless steel is equal to that of high strength aluminum alloy on a weight-ratio basis and is much higher than that of S.A.E. 1020 or S.A.E. 2315 steel. The theoretical fracture toughness of annealed stainless steel is about three times that of 24 S-T aluminum on a weight-ratio basis and three times that of S.A.E. 1020 or 2315 steel. The fracture toughness of these materials as obtained from true-stress-true-strain diagrams is found to agree within 14 per cent with values determined from tension impact tests. The significance of both elastic and fracture toughness is discussed.

Report of Committee A-1 on Steel. N. L. Mochel, Chairman.

Report of the Joint Committee on Effect of Temperature on the Properties of Metals. E. L. Robinson, Chairman.

The Effects of Temperature and Material Structure on the Fracture Properties of Medium-Carbon Steel. Julius Miklowitz, Westinghouse Electric Corp.

The results of tension tests on two medium carbon steels are presented, in which the temperature of testing and material structure have been varied. Variations in temperature of testing, and size of grain and type of pearlite in the structures of a silicon-killed and silicon-aluminum-killed steel, have produced differences in the ductility and strength values. At all temperatures, a high strain at fracture, in the minimum section of the neck, favored in general the spheroidized pearlite and fine-grained structure, and the silicon-killed steel. A high average true-stress at fracture, in the minimum section of the neck, favored the fine pearlitic structure. Grain size was of lesser importance here. The silicon-aluminum-killed steel was the stronger.

A series of Charpy impact tests favored the fine grain and fine or spheroidized pearlite for low-temperature toughness.

The fracture stress increased with a decrease in temperature of testing from 24.5 to −65 C. The strain at fracture decreased with a decrease in temperature of from −20 to −65 C. The impact strength dropped severely with temperature decrease over the whole range.

The decrease in ductility in the tension tests, with a decrease in temperature and change in material structure, was accompanied by a transition from the ductile cup and cone fracture to a fracture of abrupt crystalline nature. A similar phenomenon was apparent in the drop of the impact energy with temperature.

Effect of Manufacturing Practice on Creep and Creep-Rupture Strength of Low Carbon Steel. G. V. Smith and E. J. Dulis, United States Steel Corp.

Comparative creep to rupture tests were made at 850 F. on 12 heats of low-carbon steel made by different melting and deoxidation practices. Included were examples representing essentially the gamut of practices employed commercially. The results are reported in terms of the relation between initially applied stress and rate of creep as well as time to rupture. In addition, data are presented that permit calculation of the total amount of creep. The elongation and reduction of area of the samples tested to fracture are given.

The results show a wide variation in strength dependent upon the manufacturing practice employed, and, since they represent commercial heats, will no doubt be of considerable practical importance in the use of carbon steel in creep service.

Specimens not tested to rupture in creep at 850 F. were examined in notch impact strength at atmospheric temperature and both these specimens and those tested to rupture at 850 F. were examined microscopically for evidence of microstructural changes.

The Time Delay for the Initiation of Plastic Deformation at Rapidly Applied Constant Stress. D. S. Clark and D. S. Wood, California Institute of Technology.

The design and construction of a special rapid load testing machine is described with which tensile loads may be applied to a specimen within 5 millisec. and longer. Tests made on an annealed low-carbon steel and five other materials are presented and discussed. A definite time delay is observed for the initiation of plastic strain in the low-carbon steel, but not in the five other materials. The results are significant in the utilization of some materials under rapidly applied stresses to be sustained for short duration.

Wednesday, June 29 1.30 p.m. Eleventh Session

Held Simultaneously with the Ninth and Tenth Sessions

Electrical Insulating Materials, Quality Control, Textiles, Adhesives, Plastics, Fuels

Report of Committee D-3 on Gaseous Fuels. A. W. Gauger, Chairman.

Report of Committee D-5 on Coal and Coke. W. A. Selvig, Chairman.

Report of Committee E-11 on Quality Control of Materials. H. F. Dodge, Chairman.

Some Problems in the Sampling of Bulk Materials. Louis Tanner, Customs Laboratory, and W. Edwards Deming, Bureau of the Budget.

The sampling of shipments of bulk materials for the purpose of estimating the total weight and the average quality present various kinds of difficulties, both theoretical and practical. In order to use the statistical theory for the sampling of finite populations, it is necessary for the shipment to be divisible into sampling units in such manner that every particle of the shipment lies in one and only one sampling unit. This condition is met by packaged materials, an example being wool in bales, from which cores may be drilled in specified positions. A sample of bales may be drawn from the shipment, and a sample of cores may be taken from the sample bales, these cores then to be tested to furnish an estimate of the average quality of the shipment. The total weight of the shipment may be estimated from the weights of the sample bales. Statistical theories have been developed and are here applied in the development of procedures for drawing the bales and the cores, and for regulating the precisions of the estimated total weight and average quality of the shipment. Such methods have wide applicability. However, other types of statistical procedures, involving theories for the analysis of an infinite supply, must be developed for materials such as a pile of coal which cannot readily be divided into definite small units. Little has been done on such problems, but indications point to distinct advantages of sampling such materials at the source of supply. Hazardous biases and uncontrolled errors of sampling may be encountered through failure to regard statistical principles.

Report of Committee D-13 on Textile Materials. H. J. Ball, Chairman.

Report of Committee D-12 on Soaps and Other Detergents. F. W. Smither, Chairman.

Report of Committee D-9 on Electrical Insulating Materials. C. T. Hatcher, Chairman.

The Evaluation of Mineral Transformer Oil Frank M. Clark, General Electric Co.

This paper summarizes and analyzes the voluminous test data which have been accumulated during the five years that Section B, Subcommittee IV, Committee D-9 has been investigating the behavior of mineral transformer oil in commercially operating transformers located on the lines of the Detroit Edison Co., Commonwealth Edison Co., American Gas Co., and New England Power Co. The object of this work has been to evaluate the changes in mineral transformer oil which occur during the commercial use of the oil in different types of transformers, such as the conservator type, the nitrogen sealed type and the open-breather type. The oils investigated cover a wide variety of refining including a transformer oil which is standard for American practice.

The study also involves a critical review of the various test methods which have been considered satisfactory for evaluating new oil. These tests include sludge accumulation and high-pressure sludge tests which are at present tentative standards of the ASTM, the color, acidity, steam emulsion, and interfacial tension tests. Within the scope of the present analysis, the pressure oxidation sludge test and the interfacial tension test seem most promising for use to determine the chemical condition of mineral oil during commercial use in transformers.

Five Laminates Under Fatigue, Creep, and Static Loads. William N. Findley and W. J. Worley, University of Illinois.

Results of mechanical tests of the following laminated plastics are reported: canvas laminate molded at low pressure, grade-C canvas laminate, rayon laminate, paper laminate, and polyester glass-fabric laminate. The following tests were performed on these materials: static tension, compression, and torsion tests; long-time creep tests at different stresses, fatigue tests of unnotched specimens in bending; fatigue tests of notched specimens in bending; fatigue tests in bending at temperatures of −75, 77, and 160 F.; and fatigue tests in torsion. The data include 33 creep curves and 26 *S-N* diagrams.

A new term which may be useful for describing creep resistance is proposed together with supporting evidence. The data on fatigue strength of the five laminates indicate that the relationship between the fatigue strength of laminates and the absolute temperature may be expressed by a power equation within the limits of the data.

Report of Committee D-14 on Adhesives. Frank W. Reinhart, Chairman.

Fatigue Tests of Cycleweld Adhesive Joints. William N. Findley and Bernard A. Century, University of Illinois.

Results of fatigue tests of aluminum-alloy joints bonded with cycleweld adhesive are presented. Single-lap, double-lap, and butt joints were tested in an axial-load fatigue machine. The lap joints subjected the adhesive to shear stress and the butt joint subjected the adhesive to tensile stresses.

The project was started as a result of the activity of ASTM Committee D-14 who are preparing a fatigue test method for adhesives. The methods of testing and the merits of the three procedures employed are discussed.

Report of Committee C-19 on Structural Sandwich Constructions. A. G. H. Dietz, Chairman.

Wednesday, June 29

Cocktail Party 6.30 p.m.
and
Annual Meeting Dinner 7.30 p.m.

The Philadelphia District, through its Council, is acting as the official host for this Annual Meeting. It has arranged a Cocktail Party and informal Dinner at which there will be some outstanding entertainment. The Council felt that the members might welcome some period during the Annual Meeting of a distinctly social nature and with the approval of the Society officers, has arranged this feature. The Cocktail Party will be on a "dutch" basis, starting at 6:30 p.m. in the Garden Room, with Dinner to follow at 7:30. There is to be dinner music and following this, three or four interesting and coordinated entertainment acts, by outstanding performers, will take place. A form for dinner reservations will be mailed to members later in May.

The Philadelphia District Council is also arranging for Ladies' Entertainment, and is including the dinner in this program since the performances will be of interest not only to the members, but to their wives and families.

Thursday, June 30 9.30 a.m. Twelfth Session

Symposium on Evaluation Tests for Stainless Steels

Report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys. Jerome Strauss, Chairman.

Symposium on Evaluation Tests for Stainless Steels

There always has been a need for a laboratory testing technique that could be used to establish the effects of composition or heat treatment, or both, on the corrosion-resisting characteristics of stainless steels. On this basis, certain more or less standard corrosion-testing techniques have been devised and applied. Of necessity, these testing techniques have required the use of specific corrosive media under arbitrarily chosen testing conditions with respect to chemical concentration, temperature, duration of test, and the like. The most used of these testing methods have been the boiling nitric acid test as covered by A.S.T.M. Designation A 262–44 T, the so-called Strauss or acid copper sulfate test, and to a lesser extent, tests in mixtures of nitric and hydrofluoric acids.

The use of these test methods has helped a great deal in the development of improved compositions and heat treatments. However, there has been a very natural tendency to question the ultimate significance of results of these arbitrary tests in establishing the suitability or lack of it or particular compositions of stainless steel for particular conditions greatly different in the nature of the corrosive media and other conditions from those covered by the laboratory test methods. Recently these questions have been of particular interest in connection with the development of the extra low-carbon stainless steels and with the comparison of titanium and columbium as stabilizing elements.

This symposium, therefore, has been arranged to provide a review of experience with these evaluation test methods and the relation of results secured with them to the performance of the stainless steels under actual conditions of use.

Present Knowledge of Low Carbon 18–8. H. W. Gillett, Battelle Memorial Institute.

The data reported in the literature upon austenite stability, carbide precipitation, weldability and corrosion resistance of low, carbon 18–8 are reviewed. Not only carbon but nitrogen as well, must be impractically low to make 18–8 absolutely resistant to precipitation and grain boundary corrosion under any and all conditions of sensitization and corrosion.

This absolutely resistant condition is not required under most conditions of service. Commercially obtainable low-carbon and moderate nitrogen contents appear adequate to avoid sensitization upon cooling from welding under usual conditions, but evidence on this score is chiefly indirect.

Artificial, conventional methods for evaluating sensitization and corrosion resistance are incompetent to appraise truly the material for a given actual service. Specifications calling for such tests may discard perfectly satisfactory material.

Corrosion Resistance and Mechanical Properties of Low Carbon Stainless Steels. D. C. Buck, J. J. Heger, F. J. Phillips, and B. R. Queneau, Carnegie-Illinois Steel Corp.

The corrosion resistance and mechanical properties of a series of 69 production heats of low carbon (0.030 per cent max.) 18-8, 18–8 columbium, 18–8 molybdenum, and 18–8 molybdenum columbium were investigated.

The results of this investigation indicate that these low-carbon steels are satisfactory substitutes for the higher carbon, titanium, and columbium stabilized grades for applications, such as welding, that involve short heating times.

Accelerated Corrosion Testing of Chromium-Nickel Stainless Steel Weldments. F. K. Bloom and M. E. Carruthers, Armco Steel Corp.

Accelerated corrosion tests on metal-arc welded specimens of 0.06 per cent carbon and 0.03 per cent maximum carbon chromium-nickel stainless steel were conducted in hot nitric-hydrofluoric acids, boiling 65 per cent nitric acid and boiling copper sulfate-sulfuric acid solution. The results are compared with field experience with a welded pickling tank where both types of alloys were used.

The three common corrosion tests differ markedly in their attack on weld heat-affected zones. The nitric-hydrofluoric acid test appears to be the severest criterion of susceptibility to weld decay.

Service results, where the corrosive conditions were severe, compared well with laboratory tests and confirmed the fact that the 0.03 per cent maximum carbon alloys are free from harmful carbide precipitation in the as-welded condition.

(Continued in the Fifteenth Session)

An Appraisal of Methods for Evaluating the Corrosion Resistance of Stainless Steels. M. H. Brown, W. B. DeLong, and W. R. Myers, E. I. du Pont de Nemours & Co., Inc.

A comparison is made of results obtained by (1) boiling 65 per cent nitric acid tests, (2) 10 per cent HNO_3–3 per cent HF solution tests and (3) acidified copper sulfate solution tests on 18–8 and 18–8 Mo stainless steel in various conditions of heat treatment. These tests are commonly used to detect susceptibility of stainless alloys to intergranular corrosion. A statistical summary of the results of routine boiling 65 per cent nitric acid test evaluations of approximately 10,000 heats of stainless castings is presented. Several examples of service failures of stainless equipment by intergranular corrosion are described.

Some Observations on Tests for Intergranular Susceptibility of 18–8 Mo Stainless Steels. Hilmer Eoling and M. A. Scheil, A. O. Smith Corp.

It has been the intention of the authors of this paper to focus attention to the tests used to determine the susceptibility to intergranular attack of stainless alloys. It is pointed out that a large number of variables exist in the present testing practice and that a standard practice should be inaugurated.

A series of tests were made on Type 316 alloys to determine the effects of the stabilizing heat-treatment temperature (1550 and 1650 F.), stabilizing heat-treatment time, and the cooling rate after the stabilizing heat treatment. It is shown that the cooling rate after stabilizing is important since it can effect sensitization of the alloy. Another series of tests were made to study the effects of sensitizing Type 316 alloys at 800 and 900 F. for 500 hr. after the stabilizing heat treatment. In these tests commercial Type 316 alloys failed in the Strauss test; however, some low-carbon (0.03 per cent C max.) Type 316 alloys sustained sensitizing at 800 F. for 500 hr. but not 900 F. for that time under certain test conditions.

Some tests were made on Type 316 + Cb in order that some comparison could be made with the low-carbon Type 316.

In another series of tests, specimens of low-carbon Type 316 and Type 316 Cb were sensitized at 900 and 1020 F. for times up to 1000 hr. The results of these tests show that the low-carbon Type 316 alloy will sensitize at the low temperature if held for a sufficient length of time.

Thursday, June 30 11 a.m. Thirteenth Session

Held Simultaneously with the Fourteenth Session

Report Session—Non-Ferrous Metals

Report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought. G. H. Harnden, Chairman.

Report of Committee B-9 on Metal Powders and Metal Powder Products. W. A. Reich, Chairman.

Report of Committee B-2 on Non-Ferrous Metals and Alloys. Bruce W. Gonser, Chairman.

Report of Committee B-6 on Die-Cast Metals and Alloys. J. R. Townsend, Chairman.

Report of Committee B-1 on Wires for Electrical Conductors. J. H. Foote, Chairman.

Report of Committee E-2 on Spectrographic Analysis. B. F. Scribner, Chairman.

Thursday, June 30 11 a.m. Fourteenth Session

Held Simultaneously with the Thirteenth Session

Paint, Naval Stores, Wood, Appearance

Report of Committee D-1 on Paint, Varnish, Lacquer, and Related Products. W. T. Pearce, Chairman.

Surface Preparation and Repainting of Structural Iron and Steel. Arnold J. Eickhoff, National Lead Co.

An early report on the Evaluation of Surface Treatment of Steel Prior to Painting may be noted in the A.S.T.M. *Proceedings*, Vol. 47, p. 264. Subcommittee XXIX, Committee D-1 decided that valuable information could be derived from a study of the surface preparation and repainting of the panels reported in the above *Proceedings*.

As a result of the second phase of the study, practical and useful data were obtained concerning:

1. The optimum corrosion rating of a painted steel surface when repainting is economically desirable.
2. A comparison of three chemical pretreatments.
3. A comparison of surface condition at the time of painting, that is, sandblasted *versus* rusted *versus* mill-scale steel.
4. The difference in rate of corrosion in a rural and an industrial atmosphere.

Report of Committee D-17 on Naval Stores V. E. Grotlisch, Chairman.

Report of Committee D-7 on Wood. L. J. Markwardt, Chairman.

Report of Committee E-6 on Methods of Testing Building Constructions. J. A. Liska, Chairman.

Report of Committee E-12 on Appearance. M. Rea Paul, Chairman.

Thursday, June 30 2 p.m. Fifteenth Session

Held Simultaneously with the Sixteenth and Seventeenth Sessions

Symposium on Evaluation Tests for Stainless Steels (*Continued*)

Influence of Carbon and Molybdenum on the Intergranular Corrosion Resistance of Austenitic Chromium-Nickel Steels With and Without Columbium. W. O. Binder and C. M. Brown, Union Carbide and Carbon Research Laboratories, Inc.

Comparative intergranular corrosion tests have been made on five types of 18–8 steels containing 0.06 and 0.03 per cent maximum carbon, including the molybdenum and molybdenum - columbium variations. The data show that the increased corrosion rate noted in boiling 65 per cent nitric acid must be ascribed to a phase formation other than chromium carbide, when molybdenum is present in steels containing 0.03 per cent maximum carbon or sufficient columbium to combine with all the carbon. The phase is most damaging to corrosion during its formative period when it exists as an envelope of fine particles around the austenite grains. A limited study of steels containing a maximum of 0.01 per cent carbon indicates that the phase is sigma. Unlike chromium carbide precipitation, the formation of this phase does not affect the resistance of the steels to mixed nitric-hydrofluoric acids, air-free sulfuric acid, or boiling-acidified copper sulfate solution.

Comparative Corrosion Resistance of Stainless Steels in Various Acids. R. B. Mears, C. P. Larrabee, and C. J. Fetner, Carnegie-Illinois Steel Corp.

The corrosion resistances of several grades of austenitic stainless steels were determined in the boiling nitric acid test (Huey test) and compared with the corrosion resistances of these same steels in sulfuric acid solutions. Steels showing the least corrosion resistance in the nitric acid test generally proved to be the most resistant to sulfuric acid. Specimens of Types 304 and 316 stainless steel in both the annealed and sensitized conditions also were exposed to the boiling nitric acid test and to boiling solutions of lactic, phosphoric, and acetic acids. The Type 316 steel proved to be less resistant to nitric acid but in most cases was definitely more resistant to the other boiling acids than the Type 304 steel. However, microscopic examination indicated that the types of attack which developed in the annealed or sensitized Types 304 or 316 specimens in the boiling nitric acid test were qualitatively similar to the types of attack which developed in similar specimens in the other boiling acids, provided any attack at all developed.

Comparison of Plant Corrosion Test Results on Austenitic Stainless Steels with Results of Huey and Strauss Tests. H. R. Copson and H. O. Teeple, The International Nickel Co., Inc.

A comparison of results of some corrosion tests made in the field with results obtained by Huey and Strauss tests of austenitic stainless steels is presented. In general, it was found that the behavior of such steels in plant corrosive media is not necessarily predicted in a satisfactory manner by the behavior of the alloys in Strauss and Huey test solutions with the possible exception of these corrosives themselves.

Results of Some Plant Corrosion Tests of Welded Stainless Steels. G. F. Comstock, National Lead Co.

Corrosion tests of welded stainless steels were made in a number of chemical plants under regular operating conditions, and the results are compared with those obtained on the same steels tested by the standard boiling nitric acid procedure in the laboratory. The steel specimens included Types 304, 321, and 347 sheets, welded with Types 308, 321, and 347 electrodes, respectively, and tested both in the as-welded and stress-relieved conditions.

Testing Multiple Specimens of Stainless Steels in a Modified Boiling Nitric Acid Test Apparatus. W. B. De Long, E. I. du Pont de Nemours & Co., Inc.

An apparatus which permits the simultaneous exposure of thirty specimens is described. The test acid is continuously redistilled and corrosion product accumulation minimized by displacing them into a container separate from the one in which the samples are exposed. Results slightly lower but consistently proportional to those shown by the standard test are obtained.

Report of Committee A-6 on Magnetic Properties. R. L. Sanford, Chairman.

Thursday, June 30 2 p.m. Sixteenth Session

Held Simultaneously with the Fifteenth and Seventeenth Sessions

Plastics

Report of Committee D-20 on Plastics. G. M. Kline, Chairman.

Impact Testing of Plastics—Elimination of the Toss Factor. Bryce Maxwell and L. F. Rahm, Princeton University.

The problems encountered in the measurement of the impact strength of plastics are discussed. A new method of measuring the impact strength of polymeric materials which eliminates some of these problems is presented. The apparatus is described and the results of tests on several materials both by the new method and the standard method are tabulated. Comparison of results shows that this new method ranks materials in the proper order as indicated by the service performance of the materials. Experiments are described which lead to the conclusion that the impact strength as determined by this new method is independent of the mass of the broken sample. This permits testing over a wide range of velocities to which this method is easily adapted.

Flexure Testing of Plastic Materials. J. W. Westwater, University of Illinois. (Formerly with University of Delaware.)

Seven factors concerning flexural testing of plastics were subjected to theoretical and experimental investigation. Rectangular beams, simply supported and loaded at the mid-span were used. The results show that ignoring the horizontal reactions of the supports, the choice of radii of the contacts, or the variability of commercial materials, may lead to appreciable error. Effects due to variable beam over-hang or to excessive beam curvature are ordinarily negligible. Application to one material of the flexure-tension-compression correlation outlined by Nadai indicates that nearly pure tensile and compressive stresses exist within bent beams of this material. The effects of variable span-depth ratio are discussed.

Creep Tests of Polystyrene and a Melamine-Glass Laminate at Three Temperatures: and Correlation with Activation Energy Theory. William J. Worley and W. N. Findley, University of Illinois.

In this paper the results of creep tests of polystyrene and a glass fabric laminate bonded with a melamine resin are reported. The tests were conducted at three different temperatures, 40, 77, and 130 F. for a time interval of about 2000 hr. Specimens were tested at several different stresses for each of the three temperatures. The relative humidity of the air surrounding the specimens was maintained constant at about 50 per cent for all tests.

Dimensional changes under no stress and changes in weight of the material were recorded as well as creep. No change occurred under these conditions in either dimensions or weight.

Correlations of these data with the activation energy theory are discussed.

The Creep Characteristics of Compression Molded Polyethylene. G. R. Gohn, J. D. Cummings, and W. C. Ellis, Bell Telephone Laboratories, Inc.

Data are presented on the creep properties of compression-molded polyethylene and polyethylene compounds containing carbon black and an antioxidant. The data covered periods up to three years at various stress levels ranging from 50 to 1000 psi. The effect of shelf aging and artificial weathering on creep are indicated. Data are also given indicating the recovery upon removal of load.

Creep-Time Relations for Polystyrene Under Tension, Bending, and Torsion. J. Marin and G. E. Cuff, Pennsylvania State College.

This paper deals with creep-time relations of polystyrene subjected to tension, bending, and torsion, and attempts to correlate the creep deformations in torsion and bending with those in tension. The creep test data in tension show that the creep rate at 1000 hr. varies as the stress to the 4.7 power. The theoretical creep rates in torsion and bending based on the tension creep rates agree reasonably well with their experimental values.

Damping and Resonant Load-Carrying Capacities of Polystyrene and Other High Polymers. J. A. Sauer and W. J. Oliphant, Pennsylvania State College.

In this investigation the damping capacity of polystyrene has been determined by use of a resonant method. The energy absorbed per cycle has been measured as a function of stress amplitude. The results indicate that the damping capacity varies as the stress to the 2.3 power.

Additional measurements of the damping capacity in a number of other thermosetting and thermoplastic materials reveal a similar dependence of damping capacity on stress amplitude. This information is used to develop an endurance strength-damping criterion for the evaluation of the relative merits of different plastic materials under resonant load conditions.

The results of creep tests on polystyrene, together with the results of the damping tests, indicate a definite correlation between the creep rate and the damping capacity. The significance of this relation is discussed.

Thursday, June 30 2 p.m. Seventeenth Session

Held Simultaneously with the Fifteenth and Sixteenth Sessions

Symposium on Accelerated Durability Testing of Bituminous Materials

Report of Committee D-4 on Road and Paving Materials. F. H. Baumann, Chairman.

Report of Committee D-8 on Bituminous Waterproofing and Roofing Materials. J. S. Miller, Chairman.

Symposium on Accelerated Durability Testing of Bituminous Materials

The ability to predetermine how long a material will withstand the effects of weathering is of inestimable value to both the producer and the user. A means of determining and measuring durability or resistance to weathering of materials by an accelerated method has been a problem of long standing in many fields. In the realm of bituminous materials especially this problem has been one upon which many interested in technical research have focused their attention. Many devices and test methods have been tried, one of the well-known devices being the weatherometer.

In A.S.T.M. two technical committees, D-4 on Road and Paving Materials and D-8 on Bituminous Waterproofing and Roofing Materials, each have an active subcommittee concerned with the particular subject. The study given by these committees to date has pointed out the need for standardization in testing procedure and apparatus. This symposium is an attempt to lay the foundation for this standardization by the presentation of a group of papers by recognized authorities in this field presenting accumulated data on related phases of durability and accelerated service tests.

The symposium consists of thirteen papers touching on such factors as the effect of ultraviolet light and water, mineral stabilizers, characteristics of carbon and light sources, the use of an abrasion test, immersion-compression comparison with traffic tests, and the design and application of a spark-gap instrument. In general, the symposium papers cover all bituminous materials—asphalt, tar, and pitches and their uses for both highway and roofing purposes.

A Review of Accelerated Test Methods for the Evaluation of Road Tars. E. O. Rhodes, Koppers Company, Inc.

Characteristics of Carbon Arc Light Sources for Accelerated Exposure Testing. W. W. Lozier, M. R. Null, and F. T. Bowditch, National Carbon Company, Inc.

This paper will describe intensity and spectral distribution characteristics of carbon arc light sources in common use for accelerated testing. Data will be given on the radiant intensity in the ultraviolet, visible, and infrared regions. Comparison with solar radiation will be made. Description will also be presented on the effect of various filters which can be used to improve the similarity to solar radiation.

Behavior of Bituminous Road Materials Under Accelerated Exposure Conditions and Laboratory Heat Tests. Richard H. Lewis, Public Roads Administration.

The exposures of bituminous materials, asphalt cements, liquid asphaltic materials, and road tars, in thin films and as binders in molded specimens and, in one case, in mixtures in a circular track under simulated traffic conditions are briefly discussed. The changes that occur under these varied conditions are correlated and compared with the changes that occur in these materials when subjected to the action of the laboratory heat tests, volatilization, residue of specified penetration, and distillation tests. It will be shown that, although considerable alterations occur in these laboratory tests, hardening and changes in the characteristic of the residues are greatly accelerated under exposure conditions. It is indicated that some modifications of existing test methods are necessary to evaluate the probable road behavior and relative durability of bituminous road materials.

Accelerated Weathering of Road Tars. E. W. McGovern, Koppers Company, Inc.

Briefly discussed and illustrated are the results of several experiments to determine the effects of oxidation and evaporation on thin films of tar using air and an inert gas, and also the effects of large volumes of oxygen, nitrogen, and air on small volumes of tar. Covered, also, are the correlation of accelerated weathering data on various tars used in experimental surface treatments with their service on the road, and the application of the accelerated weathering data in the quality control and prediction of the durability in service of road tars.

Immersion-Compression Tests Compared with Laboratory Traffic Tests on Bituminous Concrete. A. T. Goldbeck, National Crushed Stone Assn.

For about 18 years the circular testing track of the National Crushed Stone Assn. has been used as a practical test for evaluating the relative durability of bituminous concrete surface mixtures when subjected to the action of traffic and water. Recently, the immersion-compression test has been proposed as a simple and rapid means for determining the effect of water on bituminous concrete and it would seem that a comparison of these two accelerated tests should throw light on their true significance. Such a comparison has been made in several series of comparative tests and as a result, some indication of the meaning of the results of these respective tests has been obtained.

The Use of an Abrasion Test as a Measure of Durability of Bituminous Mixtures. John H. Swanberg and W. L. Hindermann, Minnesota Department of Highways.

In an attempt to evaluate or predict the field performance of asphalt-aggregate systems a limited amount of work has been done employing an abrasion test involving the use of the Deval abrasion machine. As measured by this test some asphalt-aggregate combinations are inferior to others in their resistance to stripping. The test appears capable of evaluating the effect of the addition of antistripping agents in varying amounts. There appears to be reasonably satisfactory correlation with the immersion-stability test.

Test Method for Performing Accelerated Durability Tests on Asphalts. T. E. Stanton, California Division of Highways.

(Continued in the Twentieth Session)

Thursday, June 30 8 p.m. Eighteenth Session

Held Simultaneously with the Nineteenth Session

Concrete, Thermal Insulating Materials

Report of Committee C-7 on Lime. W. C. Voss, Chairman.

Report of Committee C-16 on Thermal Insulating Materials. Ray Thomas, Chairman.

A Wetting and Drying Test for Predicting Cement-Aggregate Reaction. C. H. Scholer, Kansas State College.

This paper presents a method of determining the probability of a cement-aggregate reaction in any combination of proposed mixture of cement, fine aggregate, and coarse aggregate. The test essentially consists of subjecting specimens of concrete, approximately 3 in. by 4 in. by 16 in. in length, to exposure to alternate drying at a raised temperature and wetting immersed in water at room temperature, with one cycle being completed in 24 hr.

The method has proved to be very sensitive and quite rapid. For the extremely rapid reactions that may be secured with unusually high-alkali cement and reactive aggregates, it is much faster than the commonly accepted mortar bar test in a sealed container. The test is much more sensitive in that many combinations which do not show reaction under the commonly accepted mortar bar test are revealed by the wetting and drying test.

Engineering Properties of Coral Reef Materials. C. Martin Duke, University of California. (Formerly Pacific Islands Engineer, Guam.)

For engineering purposes the tropical calcareous earth materials derived from coral reefs may be classified as coral, limestone, and cascajo, with coral the ancestor of the other two. Using this classification, a basis is suggested for the systematization of our knowledge of the engineering properties of coral reef materials. Lack of such a basis heretofore has been the cause of much confusion among engineers.

The biologic and geologic aspects of coral reef formation are briefly summarized.

Results of tests on cascajo from Guam are presented. This important material exists plentifully on the older tropical islands. The test results, supported by experience, indicate excellent mechanical-, asphalt-, and cement-stabilization properties and fair concrete-making properties for properly selected materials.

The basic principles developed for design and construction with more conventional earth materials have been found to apply in practically full force to reef-derived materials.

A bibliography is given on origin and growth of coral reefs and on properties of reef-derived materials.

Report of Committee C-9 on Concrete and Concrete Aggregates. K. B. Woods, Chairman.

Sanford E. Thompson Award

Chemical Reactions of Indiana Aggregate in Disintegration of Concrete. Floyd O. Slate, Purdue University.

This study was made to determine whether or not chemical reactions of aggregates played an important part in the disintegration of Indiana's concrete pavements. Previous field work had shown a positive correlation between disintegration and type of coarse aggregate. In the present study, two general approaches were used. First, a series of widely accepted empirical tests for chemical reactivity between cement and aggregate were run (expansion bar tests, alkali-immersion pat tests, and alkali-reactivity "bomb" tests) on most of the major types of Indiana's limestone aggregates, and some of the gravels—both good and bad. Second, several specific tests were made on the suspected reactants (chemical analysis of aggregate, petrographic analysis of aggregate, petrographic analysis of disintegrated concrete, macroscopic examination of disintegrated concrete, and others). For the aggregates studied, no appreciable chemical action was found which would cause disintegration of concrete.

Concrete for Airport Runways. Inge Lyse, Norway Institute of Technology.

The Design of Concrete Mixes Containing Entrained Air. Thomas H. Thornburn, University of Illinois.

The use of concrete containing entrained air for highway pavements has created a demand for a reliable method of concrete mix design. This investigation has indicated that mortar-voids curves obtained from tests on mortars containing entrained air cannot be used as a reliable basis for design. It was found, however, that the relationship between compressive strength and cement-space ratio for both mortars and concrete is not appreciably changed by the presence of entrained air. On this basis, a design procedure is suggested which appears to be at least as accurate as the best procedures used in the proportioning of ordinary concrete.

Thursday, June 30 8 p.m. Nineteenth Session

Held Simultaneously with the Eighteenth Session

Round-Table Discussion on Standards for Water-Borne Wastes

Report of Committee D-19 on Industrial Water. Max Hecht, Chairman.

Round Table Discussion on Need for Standards for Examination of Water-Borne Industrial Wastes

Most of the present standard methods for water analysis may be classed as end-use methods, based as a rule upon low concentrations of contaminants. The study of water-borne industrial wastes *per se* deals with high concentrations, and not after dilution in bodies of water. The wastes likewise may vary widely as to simplicity or complexity. As a result there may be a choice of procedures not available for high dilutions. The best procedures for waste analysis may be as different from customary methods of water analysis as the methods for analysis of alloy steels are from the procedure for samples taken at the ore dock. Many disagreements as to the nature of pollution are not disagreements in fact but in reporting and interpretation.

The Need for Standards for the Inspection of Water-Borne Industrial Wastes. L. Kermit Herndon, Ohio State University.

The scope of the work of Committee D-19 on Industrial Water has properly included the study of various types of industrial water flowing through a plant. Industrial wastes found in these waters have recently been receiving increased attention. Recognition of the need for methods of test that will be applicable has led to the formation of a new subcommittee in D-19 to work in this field. This new subcommittee draws within its own scope functions hitherto carried out by the other subcommittees in order to focus attention upon problems peculiar to industrial wastes. Of particular interest is an attempt to characterize industrial wastes by their key components in an evaluation of their quantity and quality.

Measurement and Sampling of Water-Borne Industrial Wastes—The Collection and Protection of a Representative Sample. C. F. Hauck, Hall Laboratories, Inc.

Frequently industrial waste waters vary widely from hour to hour in both flow rates and composition. Such fluctuations make the collection of representative industrial waste water samples difficult. Furthermore, many substances ordinarily found in industrial waste waters are unstable. Consequently, to the problem of sample collection is added the problem of sample preservation. Obviously to strive for high accuracy in analyzing industrial wastes is wasted effort unless the samples have been carefully collected and preserved until examination in the laboratory.

The sample type and size, the point and manner of its collection all influence the "representativeness" of the sample. Also involved is that matter of frequency and duration of sampling which is intimately related to the cycle characteristics of the process or the operations of the plant producing the waste water. If the flow is variable it must be gaged so that the sample can be composited according to flow. Finally, good judgment must be exercised in selecting the manual and mechanical methods by which a soundly planned sampling program is carried out.

Analysis of Water-Borne Industrial Wastes. George D. Beal, Mellon Institute.

The current demand for stream "clean up" has increased the intensity of demands for the abatement of pollution by industries. To a considerable degree the existence of this type of pollution is used as an excuse to defer the construction of sewage disposal plants. Most of the chemical studies of the composition of water-borne industrial wastes made to date are based upon procedures developed for the examination of potable or boiler-feed waters or the effluents of sewage works.

Sanitary sewages have much in common, a characteristic feature being their nitrogenous character and their putrescibility. Industrial wastes, however, may run to all of the extremes known to organic and inorganic chemists. The decomposition of human wastes is fundamentally biological, but industrial wastes are frequently antagonistic to biological processes of purification.

Friday, July 1 9.30 a.m. Twentieth Session

Symposium on Accelerated Durability Testing of Bituminous Materials (*Continued*)

Durability Tests—A Word of Caution. G. L. Oliensis, Lloyd A. Fry Roofing Co.

Weatherometer and other durability tests, since they must be accelerated to be useful, must exaggerate certain destructive factors. This may interfere with other factors present in normal exposure; hence, may yield misleading results.

Since different types of durability are required in different applications, no one durability test can serve for all purposes. Hence, actual service performance, and a background of sound asphalt experience with bitumens, still remain indispensable for properly evaluating durability for a given purpose.

However, a comprehensive and long-range investigation of the relation between the behavior of bitumens and bituminous compositions in actual service, on the one hand, and their response to every one of the known special tests, on the other, may eventually reveal which of these tests shows most promise of a latent ability to forecast durability for any particular purpose, or what modifications of them will improve their value in that direction.

Effect of Ultraviolet Light and Water Upon Pitches. H. R. Beck and B. K. McKee, Mellon Institute, and W. F. Fair, Jr., Koppers Company, Inc.

Following the earlier work of Dr. Strieter in studying light and water resistance of asphaltic materials, a group of standard and experimental pitches were alternately exposed to ultraviolet light in a weatherometer and water immersion in individual pyrex containers.

At the end of five weeks' daily alternate exposure, the immersion water was titrated with sodium hydroxide to neutrality and then evaporated to dryness and the residues weighed. A few typical asphalts were included for comparison. Data were collected for eleven five-week periods. Some duplicates were submitted to outdoor exposure simultaneously.

Results demonstrate that pitches show little solubility in water under the conditions described and show no change in solubility during the periods studied; the asphalts exhibited considerable solubility for the first several five-week periods and then exhibited a decrease with time.

Mineral Stabilizers in Asphalt Roofings. F. W. Yeager, The Flintkote Co.

A New Method for Evaluating Failure of Bituminous Materials Due to Weathering. J. B. Hunter, F. C. Gzemski, and L. Laskaris, Atlantic Refining Co.

The existing methods for determining failure of asphalt due to weathering are limited, since they do very little more than predict qualitatively the weathering tendencies of asphalt. The test as it is now employed in some laboratories requires for failure a minimum of two or three asphalt break-through spots as detected visually by (1) macroscopic examination of the panel, or (2) high voltage spark, or (3) conductivity method using electrolyte.

The method described herein has been developed for the purpose of placing the study of panel failure on a more quantitative basis and at the same time obtaining a permanent record of the type of failure encountered. In this new technique, photographic paper is used to record failure. A latent image is obtained at the point or points of failure, when a high-voltage probe electrode is passed over the reverse side of the photographic paper which is in direct contact with the asphalt surface. The results on the developed paper are converted to percentages, by superimposing a transparent counting grid and determining the number of squares containing one or more black points or spots.

The Design and Application of a Spark-Gap Instrument for Detecting Crack Failures of Asphalt Coatings During Weathering Tests. A. H. Boenau and L. A. H. Baum, Socony-Vacuum Oil Co., Inc.

Information is given whereby a spark-gap instrument for the detection of crack failures in asphalt coatings can be constructed and its electrical characteristics measured and controlled.

Accelerated weathering test data are presented to allow the comparison of visual, conductivity, and spark methods of inspecting films of asphalt exposed on metal panels. The results show that no reliance can be placed upon visual observations but that both electrometric methods provide suitable means for the detection of failures and are in close agreement.

Other data from the inspection of panels exposed outdoors, however, reveal a serious weakness in the applicability of the con-

ductivity test, whereas the spark method continues to yield consistent results. It is believed that the ease of operation, the vividness of the end point, and the possibility of standardizing the spark-gap instrument are further points in its favor.

Experience with Radiation in Accelerated Durability Tests on Bituminous Materials. Joseph Zapata, United States Gypsum Co.

A brief summary is made of reported experience with the use of radiation. A systematic study of weatherometer exposures is described and the results of tests are analyzed statistically. Certain shortcomings of the testing machines are indicated. The use of electrical units is suggested for evaluating the resistance of the asphalt film to radiation. Comparisons are made between performance observed on outdoor exposures and exposure in the weatherometer.

20 to 30 Years' Weathering of Asphalt Shingles Made with Unfilled Coatings. G. L. Oliensis, Lloyd A. Fry Roofing Co.

Laboratory and weatherometer tests on asphalt coatings (such as used in ready prepared roofings) have consistently pointed to the greater probable durability of the filled than the unfilled types. In 1946, however, it was shown for the first time that actual ten-year exposure tests on large panels of coating on saturated felt had failed to bear out this trend. The present paper presents additional corroborative evidence of a number of asphalt shingle roofs made with unfilled coatings that have successfully weathered twenty to thirty years' exposure (longer than the filled coating types have been in service), and that therefore justify a reconsideration of such roofing specifications as make the use of filled coatings mandatory.

Friday, July 1 2 p.m. Twenty-first Session

Held Simultaneously with the Twenty-second Session

Report Session—Petroleum Products, Rubber, Engine Antifreezes, Hydrocarbons, Shipping Materials

Report of Committee D-2 on Petroleum Products and Lubricants. C. Dantsizen, Chairman.

Report of Committee D-15 on Engine Antifreezes. H. R. Wolf, Chairman.

Report of Committee D-6 on Paper and Paper Products. W. R. Willets, Chairman.

Report of Committee D-16 on Industrial Aromatic Hydrocarbons. D. F. Gould, Chairman.

Report of Committee D-11 on Rubber and Rubber-Like Materials. Simon Collier, Chairman.

Report of Committee D-10 on Shipping Containers. T. A. Carlson, Chairman.

PAPER ON CEMENT—Friday, July 1

Immediately following the business meeting of Committee C-1 on Cement, scheduled to begin at 9 a.m., a paper by F. R. McMillan on "Long Time Test of Cement and Concrete" will be given. All those interested are invited to attend.

Friday, July 1 2 p.m. Twenty-second Session

Held Simultaneously with the Twenty-first Session

Cementitious and Building Materials

Report of Committee C-8 on Refractories. R. B. Sosman, Chairman.

Report of Committee C-17 on Asbestos-Cement Products. H. R. Snoke, Chairman.

Size and Border Conditions of Test Specimen in Their Relation to Results of Fire Tests. S. H. Ingberg, National Bureau of Standards.

The general conditions are outlined that govern the size of test constructions that are to be subjected to fire tests, such as heat loss at the borders and influence of size and border conditions on deflection, stability, and load-carrying ability. Results of fire tests are presented illustrative of what may obtain because of differences on these particulars. The theoretical relation is given of thickness of sample to temperature difference between the fire exposed and the unexposed surface after given periods, and comparisons made with data from tests. Consideration is also given to the influence of size and border conditions on the stability of materials applied as protective coverings.

Report of Committee C-2 on Magnesium Oxychloride Cements. L. S. Wells, Chairman.

Long Time Tests of Concrete Containing Cements of Types I, II, and III Under Various Storage Conditions. W. J. McCoy and S. B. Helms, Lehigh Portland Cement Co.

This paper contains compressive strength data of ¾-in. gravel concrete up to 16 yr. for 12 cements each of types I, II, and III under three different storage conditions, namely: inside storage, outside storage and 70 deg. fog room storage. The chemical analysis, potential compound composition, and A.S.T.M. specification test data are tabulated for each cement. These tabulations permit the A.S.T.M. mortar strengths and other characteristics of these cements to be compared with the long-time concrete strengths. One interesting feature of the paper is the test data which show the performance of type III cements over a period of 16 yr. under various storage conditions.

The Use of Natural Anhydrite in Portland Cement. W. C. Hansen and J. O. Hunt, Universal Atlas Cement Co.

Studies were made to determine the possibility of replacing gypsum wholly or in part by natural anhydrite in portland cements. Seven clinkers were ground with varying percentages of gypsum and tests were made to determine the optimum amount of SO_3 for each clinker. The clinkers were then ground with this optimum amount of SO_3 in the form of mixtures of gypsum and natural anhydrite and the tests were repeated. A comparison of the results obtained with gypsum alone and with blends of gypsum and natural anhydrite showed that, with one clinker, 25 per cent and, with the others, 60 to 75 per cent of the gypsum could be replaced by natural anhydrite without adversely affecting the properties of the cements.

The Direct and Continuous Measurement of Bleeding in Portland Cement-Water Mixtures. Rudolph C. Valore, Jr., James E. Bowling, and R. L. Blaine, National Bureau of Standards.

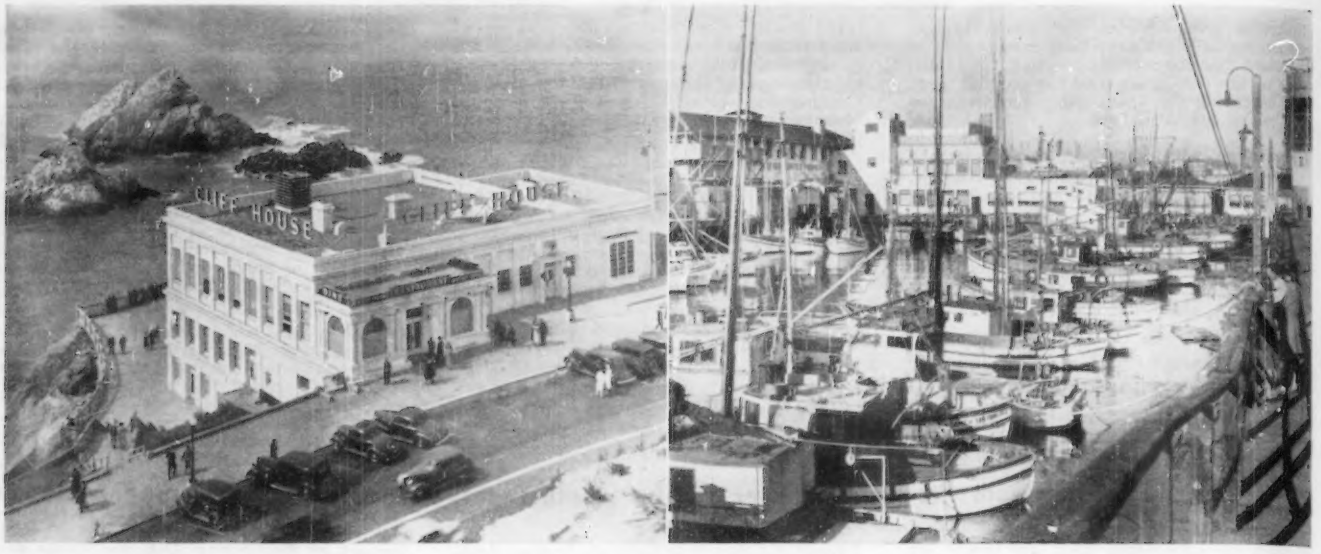
An apparatus is described for measuring bleeding in portland cement-water mixtures. Carbon tetrachloride, which is immiscible with, and heavier than, water is used as a displacement medium which, when placed over the surface of a cement-water mixture, causes the bleeding water to rise through the medium into a burette. Tests of neat cement pastes at various water-cement ratios show the method to be highly reproducible. Results are compared with those obtained in parallel tests using a float-subsidence method as employed by Powers. Results of bleeding tests of concretes and of the use of different displacement media are also given.

Report of Committee C-1 on Cement. F. H. Jackson, Chairman.

Report of Committee C-12 on Mortars for Unit Masonry. Theodore I. Coe, Chairman.

Report of Committee C-15 on Manufactured Masonry Units. J. W. Whittemore, Chairman.

Report of Committee C-18 on Natural Building Stones. L. W. Currier, Chairman.



Courtesy San Francisco Convention and Tourist Bureau

San Francisco

Extensive Technical Program at Pacific Area National Meeting

Plans for Week of October 10 in San Francisco Nearing Completion

AN EXTENSIVE and interesting program, involving 15 technical sessions with approximately 70 papers, has been planned for the Society's first Pacific Area National Meeting scheduled for San Francisco during the week of October 10. Announcement of the Committee on Arrangements for the meeting appeared in the March BULLETIN, and a list of the various committees and their chairmen is given here.

During the recent visit to the West Coast, at which time the Southern and Northern California Districts, centered in Los Angeles and San Francisco, respectively, held technical meetings, President R. L. Templin and Executive Secretary C. L. Warwick attended a meeting of the General Committee on Arrangements and Mr. Warwick held numerous conferences. In a week-long period in San Francisco, all of the subcommittee chairmen reviewed with him and the General Committee their various responsibilities.

Meeting Announcement.—About the first week in June full details of the meeting, including complete information on the technical program, hotel arrangements, entertainment and related matters will be sent to A.S.T.M. committees and members in the form of a special Pacific Area Meeting folder. Subsequently, additional information and details will be furnished through the July ASTM BULLETIN and in direct communications.

Technical Program:

Concentrated work by the Committee on Technical Program, headed by Prof. R. E. Davis of the University of California, with Prof. J. W. Kelley of the University, as Secretary, has resulted in a program with 15 technical sessions to cover the following major subjects:

Metals I (Plasticity and Creep)
Metals II (Fatigue)
Soils
Bituminous Paving Mixtures
Dynamic Stress Determinations
Ceramic and Concrete Products
Applications of Statistics
Cement and Concrete I (General)
Cement and Concrete II(Pozzolans)
Petroleum I (High Additive Content Oils)
Petroleum II (Turbine Oils)
Wood
Cast Iron
Paint I (Aircraft Finishes)
Paint II (General and Testing)

Some 70 leading technologists, all very active within their respective fields, will present the technical papers. The program is in line with the Officers' original conception of this meeting as a truly national one, and the entire program and the papers will be in keeping with the Society's reputation for sponsoring outstanding technical affairs

Certain of the A.S.T.M. technical committees have been cooperating closely in arranging some of the sessions and the June general announcement will note these groups.

Tentative Program Outline:

Sunday, October 9, the Registration Desk will be open at the headquarters hotel (the Fairmont) and on Monday there will be committee meetings morning and afternoon. Following the opening ceremonies in the early afternoon there will be conference sessions on metals and soils, with the metal session continued at night and another one on bituminous paving mixtures.

On Tuesday and remaining days there will be meetings of various technical committees, with morning sessions on dynamic stress determination, and ceramic and concrete products. In the afternoon is a session on statistics and at night a cocktail party with reception and buffet supper.

Wednesday, October 12, morning sessions involve cement and concrete, and petroleum, with similar sessions in the afternoon.

Thursday, October 13, will have wood and paint as the session topics in the forenoon, with cast iron and the second session on paint in the afternoon; at night a boat ride, with box supper and dancing, is planned.

Friday, October 14, there are no technical sessions scheduled, but instead an all-day trip is planned to the Uni-

General Committee on Arrangements

DOZIER FINLEY, *Chairman*, Research Consultant, Berkeley

C. E. EMMONS, *Vice-Chairman*, The Texas Company, Los Angeles

C. F. RAMEY, *Secretary-Treasurer*, Standard Oil Co. of California, 225 Bush St., San Francisco 20

Other members are as follows: R. F. Blanks, U. S. Bureau of Reclamation, Denver; T. P. Dresser, Jr., Abbot A. Hanks, Inc., San Francisco; W. C. Hanna, California Portland Cement Co., Colton; T. K. May, West Coast Lumberman's Assn., Portland; W. W. Moore, Dames & Moore, San Francisco.

Committee Chairmen

Technical Program—R. E. Davis, University of California, Berkeley.

Hotel—S. L. Davidson, National Lead Co., San Francisco.

Registration—F. M. Harris, Pacific Gas and Electric Co., San Francisco.

Transportation—P. V. Garin, Southern Pacific Co., San Francisco.

Entertainment—H. A. Sawin, Yuba Manufacturing Co., San Francisco.

Plant Visits—S. A. Abrahams, The Paraffine Cos., Inc., Emeryville.

Dinner—G. E. Solnar, Jr., Clay Brick Mfrs. Assn. of Northern California, San Francisco.

Publicity—T. K. Cleveland, Philadelphia Quartz Co. of California, Berkeley.

Finance—G. L. von Planck, Columbia Steel Co., San Francisco.

Liaison and Detailed Arrangements—T. S. Hersey, Hersey Inspection Bureau, Oakland.

Places of Interest

There are so many places of interest in the West, particularly the eleven states in the Pacific Area group, the members in which are acting as hosts for the Society's first national meeting west of the Rockies, that it is well nigh hopeless to include in the ASTM BULLETIN even a listing of these. In addition to California, its neighboring states all have state or national parks that will repay almost any effort to get to them, and there are numerous other points of interest that have not been set aside as part of the state or national domain.

The numerous sources of information include the various auto clubs and associations, and a series of state books issued as part of the Writers Project Series under the Works Progress Administration contain a wealth of information, much of which has not been compiled elsewhere. A number of these books are still in print, and most large libraries have the volumes.

In addition to its cities and historical points and missions, California has a number of state and Federal parks and monuments, including those noted below:

Big Basin Redwoods State Park
Cabrillo National Monument
Channel Islands National Monument
Death Valley National Monument
Devils Postpile National Monument
Joshua Tree National Monument
Kings Canyon National Park
Lassen Volcanic National Park
Lava Beds National Monument
Marshall State Monument
Mount Shasta
Muir Woods National Monument
Palomar Mountain State Park
Pinnacles National Monument
San Simeon Creek Beach State Park
Sequoia National Park
Yosemite National Park

Many of the members attending the San Francisco meeting will no doubt plan to visit some of the numerous points of interest depending on whether they go by train, by auto, or other method.

versity of California with inspection of a number of its outstanding features including the Cyclotron and the engineering laboratories, with an informal luncheon.

Some changes may develop on the timing of the sessions, so members are urged to wait for the forthcoming June announcement.

Technical Committee Meetings:

At least ten of the A.S.T.M. main technical committees are planning to hold meetings in San Francisco during the week of this National Meeting, the list being as follows:

C-1 on Cement
C-9 on Concrete and Concrete Aggregates
C-12 on Mortars for Unit Masonry
C-15 on Manufactured Masonry Units
C-19 on Structural Sandwich Constructions
D-2 on Petroleum Products and Lubricants
D-4 on Road and Paving Materials
D-7 on Wood
D-8 on Bituminous Waterproofing and Roofing Materials
D-18 on Soils for Engineering Purposes

Detailed schedules of these meetings will be sent to all the committee members by the secretaries, following exactly the same procedure used for the A.S.T.M. spring or annual meetings.

General Notes:

Sufficient commitments have been received from cooperating hotels, particularly the Fairmont and the Mark Hopkins, to assure adequate rooms for the members and those attending the meetings, and full details will shortly be furnished.

The Committee on Transportation is developing significant data on travel facilities, including possibility of a special train or special cars attached to some of the through trains.

An outstanding entertainment program has been planned, and particular attention has been devoted to the ladies entertainment.

The General Committee on Arrangements and the Subcommittee Chairmen are intensely interested in the meeting and are planning a series of events that will appeal to everyone present. Our members in the West are devoting considerable time and effort and have developed a real enthusiasm for this affair, and they are counting on greeting a large number of their fellow members and committee members from East of the Rockies.

Hotel Fairmont

Important New and Revised Standards on Steel, Paint and Paint Materials, Plastics, and Non-Ferrous Metals

On the recommendations of several technical committees, the Society through its Administrative Committee on Standards has recently approved some very important new and revised specifications and tests. These respective groups of standards, listed in the accompanying table, are extremely significant to the industry concerned and are the culmination of intensive and long time work, particularly in the subcommittees responsible.

All of these items are published in separate pamphlet form, and A.S.T.M. members can obtain a copy of the items on request without charge.

These new and revised items are not included in any of the Society's bound publications of standards, the latest being the 1948 Supplements. They will, of course, be given in their latest form in the 1949 Book of Standards to be issued late this year.

Steel:

Several of the important recommendations from Committee A-1 on Steel have been under intensive consideration and attention of the various subcommittees for many months. It was not possible to complete the items noted here in time for inclusion in the 1948 Supplements, but they are of such significance, and work has been under way for such a time, that approval now was desired so that there would be no further delay.

General Requirements for Delivery of Rolled Structural Material with Condensed Specification Requirements:

This move of establishing a new specification involving general requirements for delivery of plates, shapes and bars, A 6, which document incorporates much of the material common to the several individual structural specifications, is considered a very significant one, and its application and development will be watched with much interest, not only in the steel industry, but by a number of the other A.S.T.M. technical groups. Concurrent with the removal of tolerance tables, testing details, etc., from such specifications as A 7, covering steel for bridges and buildings, one of the oldest A.S.T.M. documents, and other important standards such as that for locomotives and cars, A 113, and the others noted, essential requirements were studied and clarified.

This study began in 1947 when it was realized that to incorporate in each individual specification all of the various tables and general requirements necessary to cover rather completely the necessary quality and related values, would mean a great amount of printing and considerable duplication among the standards. Subcommittee II on Structural Steel discussed the matter at several meetings with voluminous correspondence, and with the approval of the A-1 Advisory Committee, and eventually the main committee, established a so-called "General Specification," which is essentially part of the other product standards, and to which they refer. Chairman of Subcommittee II at the time the move was started was F. H. Frankland. His successor, C. E. Loos, Carnegie-Illinois Steel Corp., and Jonathan Jones, Fabricated Division, Bethlehem Steel Co., Inc., very active in the work of Subcommittee II for many years, and its vice-chairman, have had a leading part in this important activity. The scope clause of the new general requirement specification A 6 is as follows:

Scope

1. This specification covers a group of common requirements which, unless otherwise specified in the purchase order or in an individual specification, shall apply to rolled steel plates, shapes and bars under each of the following specifications issued by the American Society for Testing Materials:

Title of Specification	A.S.T.M. Designation[a]
Steel for Bridges and Buildings	A 7
Structural Silicon Steel	A 94
Structural Steel for Locomotives and Cars	A 113
Structural Steel for Ships	A 131
Low-Alloy Structural Steel	A 242
Structural Rivet Steel	A 141
High-Strength Structural Rivet Steel	A 195
Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality	A 283
Intermediate Tensile Strength Carbon-Silicon Steel Plates for Machine Parts and General Construction	A 284

While the changes in the condensed and revised product specifications, such as A 7 (first printed in 1899 and adopted in 1901), in general result from the removal of material now in A 6, other changes have been incorporated and numerous editorial clarifications have been made.

[a] These designations refer to the latest issue of the respective specification.

It can be said of these new specifications, that they now include most of the important requirements necessary for the designer and purchaser to get required quality from the materials. They include material that formerly was not a part of the standards, and it is believed the product specifications will be easier to use, and clearer because of the concentration on the essentials.

This move of establishing a specification with material common to several other product standards is being studied in other Committee A-1 groups, including Subcommittee XI on steel for Boilers and Pressure Vessels, and Subcommittee IX on Pipe and Tubing.

These new and revised structural steel specifications are being issued together in a pamphlet of about 36 pages so that the purchaser of the product specification will always have A 6 as part of the pamphlet for handy reference. Special prices will apply on this pamphlet, with a reduction to members.

One leading authority who has had an important part in the work believes that this move will give documents that are of greater convenience to both producer and user. The producer will know that the standard tolerances have been accepted by the user, and the user will, through representation in the A.S.T.M. committees, be able to check and discuss, and approve tables and general conditions before they are standards. In general, the new setup will provide a more satisfactory background to the whole relationship between the producer and consumer of structural steel.

Steel Bars, Boiler Plate, etc:

Continuing its work to cover (through A.S.T.M., standards) various types of bar steels that are now in commercial demand, Subcommittee XV has agreed on the requirements for heat-treated carbon steel bars and hot-rolled alloy steel bars.

In the carbon bar tentative (A 321), definite physical and mechanical properties are included, the minimum tensile strength up to 4 in. being 90,000 psi. and over 4 up to 7 in. 85,000 psi.; elongation for all sizes is 20 per cent minimum, with a 40 per cent minimum reduction of area.

The hot-rolled alloy specification (A 322) includes a wide range of chemical compositions and chemistry is the major criterion of acceptance. Full details on tolerances, check analysis, and related essential items are given.

Following issuance in 1947, the tentative covering Stress Relief Annealed Cold Drawn Carbon Steel Bars (A 311) was scrutinized and several modifications included to clarify requirements, and bring them in closer line with commercial practice.

Revisions in various boiler plate specifications involve, in some cases, the marking clause, and additional tension test specimens where adequate testing capacity is available; and in the case of nickel-steel standard A 203, include a modified nickel range, and marking and test specimen details.

The carbon-steel plate standard, A 285 for low and intermediate material 2 in. and under in thickness, has the reference to forge welding removed, and the Boiler Code requirements on copper, minimum 0.35 per cent when copper steel is specified, is added for all grades. It is reverted to a tentative.

While changes are approved in the so-called common bolting tentative A 307, they are not to be published now, but are held until further revisions are made.

Open Hearth Steel Rails:

The revisions in the open hearth steel rail specification, A 1, are not extensive. In the table headings the first two columns are changed from the present "61 to 69" and "70 to 90" to read "61 to 80" and "81 to 90" lb. per yd., respectively.

Section 7 on Ladle Analysis is to read "Separate analyses shall be made from the drillings that are taken from the test ingots representing one of the first three and one of the last three full ingots of the heat to determine the percentages of carbon, manganese, phosphorus, sulfur, and silicon. The average analyses of the ladle test ingots shall conform to the chemical requirements prescribed in Table I. A portion of the drilling shall be furnished to the inspectors, upon request, for check analysis."

Chemical Analysis of Copper Alloys:

Although Committee E-3 on Chemical Analysis of Metals has issued many standardized methods of analysis of both ferrous and non-ferrous metals, much work is still under way in the committee, and from time to time, new methods on which agreement has been reached will be issued covering other metals and alloys. The new tentative methods of analysis of copper-nickel and copper-nickel-zinc alloys (E 75) are in this category. Methods cover alloys with relatively high nickel, or high nickel-zinc content. The various procedures have been evaluated and proved in comparative tests.

Cathode Melt Prove-in Testing:

During the past few years the Cathode Section of Subcommittee VIII of Committee B-4 has been carrying out an intensive research on the emissivity of cathode nickel. As a first step, the section has worked out a uniform procedure for testing the cathodes which their experience now crystallizes into the new recommended practice (B 238).

This recommended practice describes a procedure for testing melts of cathode nickel in order to determine whether they are suitable for use in the production of electronic tubes.

Individual melts of material are tested by fabricating a portion of it into cathodes and running tests of these cathodes in a tube type of a customer's choosing. A control test, using an equal number of cathodes from an approved standard melt of the same grade, is to be run in conjunction with all test melts and both the test and control are to be run at the same time. (As of March, 1949, "Melt 66" is the standard melt of normal activity approved and being used by Committee B-4.)

Paint and Paint Materials:

Agreement was reached recently in Committee D-1 on the new method (D 1005) for measuring dry film thickness of paint and related products. There has been a demand for such a procedure for some time.

The method covers the measurement of film thickness of dried paint, varnish, and lacquer films applied to an acceptable plane rigid surface such as metal or glass. This method is not recommended for films less than 0.5 mil in thickness. It does not apply to excessively soft films.

The new method for conducting exterior exposure test of paints on wood (D 1006) will be of widespread interest because of the very general concern with this subject. This method of test is intended to determine the relative

Actions of A.S.T.M. Administrative Committee on Standards, May, 1949

New Tentatives

Specifications for:

- General Requirements for Delivery of Rolled Steel Plates, Shapes and Bars for Structural Use (A 6 – 49 T).
- Steel for Bridges and Buildings (A 7 – 49 T).[1]
- Boiler and Firebox Steel for Locomotives (A 30 – 49 T).[1]
- Structural Silicon Steel (A 94 – 49 T).[1]
- Structural Steel for Locomotives and Cars (A 113 – 49 T).[1]
- Structural Steel for Ships (A 131 – 49 T).[1]
- Structural Rivet Steel (A 141 – 49 T).[1]
- High-Strength Structural Rivet Steel (A 195 – 49 T).[1]
- Low-Alloy Structural Steel (A 242 – 49 T).[1]
- Low and Intermediate Tensile Strength Carbon-Steel Plates of Flange and Firebox Qualities (Plates 2 in. and Under in Thickness) (A 285 – 49 T).[1]
- Heat Treated Carbon Steel Bars (A 321 – 49 T).
- Hot-Rolled Alloy Steel Bars (A 322 – 49 T).
- Secondary Butyl Alcohol (D 1007 – 49 T).

Recommended Practice:

- Cathode Melt Prove-In Testing (B 238 – 49 T).

Method of:

- Testing the Strength Properties of Adhesives in Shear by Tension Loading (Metal-to-Metal) (D 1002 – 49 T).
- Test for Tear Resistance of Plastic Film and Sheeting (D 1004 – 49 T).
- Measurement of Dry Film Thickness of Paint, Varnish and Lacquer Products (D 1005 – 49 T).
- Conducting Exterior Exposure Tests of Paints on Wood (D 1006 – 49 T).
- Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys (E 75 – 49 T).

Tentative Revisions of Standards

Specifications for:

- Open-Hearth Carbon-Steel Rails (A 1 – 46).
- Carbon-Silicon Steel Plates of Intermediate Tensile Ranges for Fusion-Welded Boilers and Other Pressure Vessels (A 201 – 47).
- Molybdenum-Steel Plates for Boilers and Other Pressure Vessels (A 204 – 47).
- High Tensile Strength Carbon-Silicon Steel Plates for Boilers and Other Pressure Vessels (Plates 6 in. and Under in Thickness) (A 212 – 47).
- Manganese-Vanadium Steel Plates for Boilers and Other Pressure Vessels (A 225 – 47).

Revision of Tentatives

Specifications for:

- Nickel-Steel Plates for Boilers and Other Pressure Vessels (A 203 – 49 T).
- Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality (A 283 – 49 T).
- Low and Intermediate Tensile Strength Carbon-Silicon Steel Plates for Machine Parts and General Construction (A 284 – 49 T).
- Chromium-Molybdenum Steel Plates for Boilers and Other Pressure Vessels (A 301 – 49 T).
- Manganese-Molybdenum Steel Plates for Boilers and Other Pressure Vessels (A 302 – 49 T).
- Steel Machine Bolts and Nuts and Tap Bolts (A 307 – 49 T).
- Stress - Relief - Annealed Cold - Drawn Carbon-Steel Bars (A 311 – 49 T).

Methods of:

- Test for Ester Value of Tricresyl Phosphate (D 268 – 49 T).

[1] Reverted from their former status as Standards, and revised.

service that can be expected of paints when applied on exterior wood siding. It outlines the procedure to be followed and describes constructions suitable for the test panels and for the rack to hold them. Requirements relate to the test site location, exposure, lumber, the rack construction, and painting construction, use of control paints, and related pertinent items.

The requirements for secondary butyl alcohol (D 1007) which is used in paint, varnish, lacquer, and related products, indicate a specific gravity of 0.807 to 0.810, that it shall be miscible without turbidity with 19 volumes of 19 heptane, and cover the acidity, and appearance in color.

The revisions in the test for Ester Value of Tricresyl Phosphate, D 268, involves a change in the amount of KOH to be added in the procedure from 3 g. to read "3 g. to 6 g." and in the heating procedure, the present length of time, 30 minutes at 200 C., is to be changed to "2 hours at 200 C. or until all oil disappears."

Adhesives:

The new test method for evaluation of shear strengths of bonds between two metals (D 1002) is of great practical value and is needed for evaluation of new adhesives for metals. The method has been subject to adequate round-robin testing by Subcommittee I of D-14 on Adhesives.

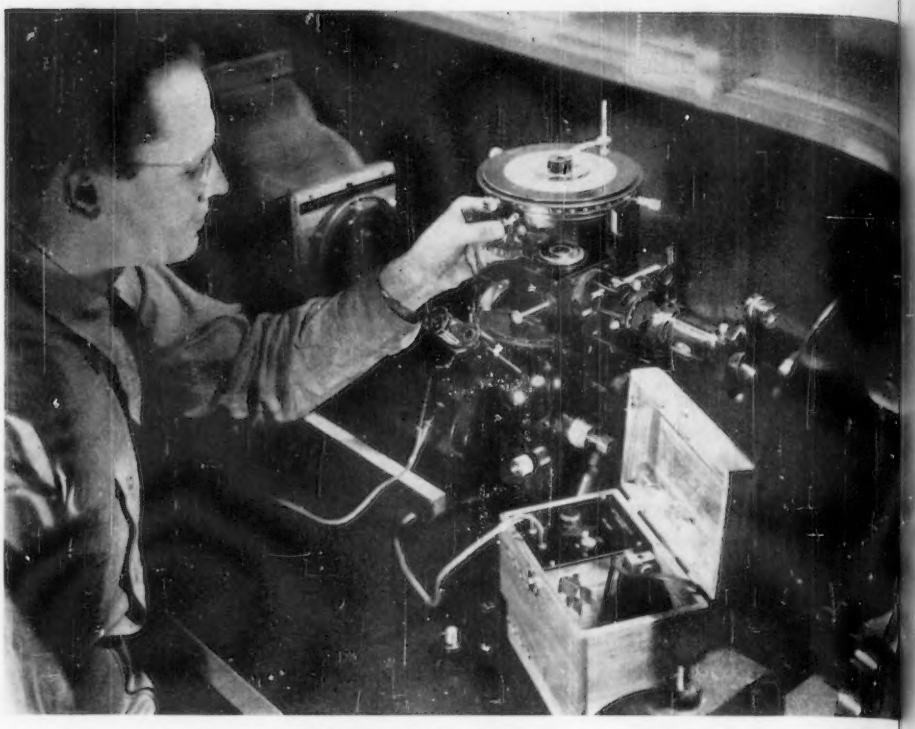
Plastic Film:

The new test for determining tear resistance of plastic films (D 1004) will meet the needs expressed by various consumers and producers. It relates to flexible plastic film and sheeting ranging in thickness from 0.001 to 0.075 inch.

Proposed Changes in Road Materials Definitions

REVISIONS of the Standard Definitions Relating to Road Materials (D 8 – 46) have been accepted for publication as tentative as set forth below:

Under the section Relating in General to Bituminous Materials, revise the definitions for bituminous, bituminous emulsion, cut-back products, and fluxes to read as follows:



"Microhardness Testing"

Third prize-winning photograph, General Section, Testing Equipment Group, in the Sixth A.S.T.M. Photographic Exhibit, by W. C. Wilke, Jr., Crane Co. Research Laboratories.

Bituminous Material.—A substance which is characterized by the presence of bitumen, or one from which bitumen can be derived.

Bituminous Emulsion.—(*a*) A suspension of minute globules of bituminous material in water or in an aqueous solution.

(*b*) A suspension of minute globules of water or of an aqueous solution in a liquid bituminous material.

Cut-Back Products.—Petroleum or tar residuums which have been blended with distillates.

Flux.—A bituminous material, generally liquid, used for softening other bituminous materials.

Under the section Relating Specifically to Petroleum or Asphalts, revise the definitions for asphalts and rock asphalt to read as follows:

Asphalt.—A dark brown to black cementitious material, solid or semisolid in consistency, in which the predominating constituents are bitumens which occur in nature as such or are obtained by refining petroleum.

Asphalt Rock (*Rock Asphalt*).—a naturally occurring rock formation, usually limestone or sandstone, impregnated throughout its mass with a minor amount of bitumen.

In the same section, delete the definitions for petroleum and topped petroleum because these terms are defined in the Standard Definitions of Terms Relating to Petroleum (A.S.T.M. Designation: D 288).

In the section Relating Specifically to Tars and Pitches, delete the definition for dead oils; also revise the definition for water-gas tar to read as follows:

Water-Gas Tar.—Tar produced by cracking oil vapors at high temperatures in the manufacture of carburetted water-gas.

In the section Relating in General to Nonbituminous Materials delete the definition for matrix.

Plan to Attend the First A.S.T.M. Pacific Area National Meeting—A Strong, Diversified Technical Program—Committee Meetings—Appropriate, Interesting Entertainment—all at a time when California and its leading cities, Los Angeles and San Francisco, and many other points in the Pacific Area are at their best.

Full details in a direct mailing to all members and committee members early in June.

Make your plans now!

New Publications—Technical Symposiums and Compilations of Standards

SEVERAL new books have recently been issued and a number are in course of publication which will be of considerable interest, particularly to those groups working in the industries concerned. Two of the publications are special compilations of standards—one issued for the first time giving all specifications and tests on *light metals and alloys;* the second, a new edition of the widely used compilation on *rubber and rubber-like materials.*

Symposiums which have been issued cover the following: Magnetic Testing, Metallography in Color (June, 1949), Deformation of Metals, and Industrial Gear Oils.

These six books, together with the Marburg Lecture that had been reprinted from the *Proceedings* in separate pamphlet form, and a new printing of the book "Properties of Metals at Subatmospheric Temperatures," were included in a Members' Order Blank for A.S.T.M. Publications sent out early in April, thus giving members an opportunity conveniently to order these books at the special prices to members.

Compilations of Standards

Light Metals and Alloys:

While the Society has been working in the field of light metals and alloys, particularly on aluminum and magnesium, for many years, and has issued quite a number of tests and specifications, many resulting from intensive research work, it was not until recently that a need was apparent for a special compilation of all of the standards. In recent years Committee B-7 has made important progress with a number of new standards and it is felt this book will serve a real need. This first edition, 160 pages, sponsored by Committee B-7 includes not only those specifications and methods of test which come under the jurisdiction of Committee B-7 (ingots, castings, wrought products), but also those for light metal alloy die castings, prepared by Committee B-6 on Die Castings, and those for aluminum wire and cable for electrical purposes, sponsored by Committee B-1 on Wires for Electrical Conductors. Several methods under the jurisdiction of Committee E-1 on Methods of Testing and Committee E-3 on Chemical Analysis of Metals have been added so that the compilation will be as useful as possible. In addition, a specification for aluminum and aluminum alloy arc-welding electrodes under the jurisdiction of the A.W.S.-A.S.T.M. Joint Comittee on Filler Metal has been included. There are 36 specifications and methods of tests. Copies of this compilation can be procured by the members at $1.75, the list price being $2.25. Reduced prices are in effect on orders in quantity.

Rubber and Rubber-Like Materials:

Down through the years since its organization in 1912, A.S.T.M. Committee D-11 on Rubber and Rubber-Like Materials has been a very important force in this industry. The consumers and producers of rubber products represented on the committee have carried out a tremendous amount of research work, and a large number of specifications and test methods have been established, the methods involving a wide variety of tests on numerous products, physical and chemical tests, and others.

The newest compilation of standards issued late in February is a very extensive book of almost 600 pages with 81 A.S.T.M. standards and tentatives. It covers widely used rubber products, including processibility tests, methods of sampling and chemical analysis, and numerous physical tests. The latter cover hardness, tear, tension, adhesion, cure, etc., and there are aging and weathering tests, low-temperature tests, electrical tests, and standard nomenclature and definitions. Groups of specifications cover: automotive and aeronautical rubber, rubber hose and belting, gloves, matting, tape, rubber-coated fabrics, insulated wire and cable, hard rubber and cellular rubber, rubber cements and latices, packing materials, nonrigid plastics, electrical tests, nomenclature and definitions. Rubber technologists, sales engineers, all who are concerned with the purchase of rubber products, and many others in related positions should find this compilation of service.

Copies of this book in heavy paper cover can be purchased by the members at $3.40, the list price being $4.50, with reduced prices in effect on orders in quantity.

Technical Symposiums

Among the most important contributions of the Society to the field of materials are the authoritative papers or collections of papers covering various problems and aspects of a wide variety of technical subjects. Always at A.S.-T.M. Annual Meetings and frequently at Spring Meetings and other sessions there are symposiums or special groups of technical papers. The participation in these symposiums of many of the country's outstanding authorities gives to the pamphlets and books when they are published, a ring of authority. Furthermore, the symposium books are carefully edited, frequently under the guidance of a symposium committee, each paper being reviewed by one or more men cognizant of the particular field before its acceptance. The inclusion of discussion presented at the meeting or subsequently in writing gives a breadth of view which many have found to be one of the important attributes of an A.S.T.M. publication.

The following notes on the new symposiums may be of interest to those concerned.

Magnetic Testing—STP 85:

Presented at the 1948 Annual Meeting in Detroit, this symposium includes eleven technical papers. The rapid development of new and superior magnetic materials in recent years has given rise to new and often difficult problems in connections with magnetic testing, and, also, there has been continued activity and development in the field of magnetic analysis by which the condition and quality of materials are determined from the results of nondestructive magnetic tests. Subjects covered include:

- Testing magnetic materials
- Permanent magnet testing methods and their validity in determining product performance
- Core loss test for narrow silicon steel strip
- D-C permeability testing of Epstein samples
- Variation of core loss
- Evaluation of hysteresis core loss by power equations
- Magnetic analysis inspection in the steel industry
- Magnetic stress analysis
- Testing of magnetic recording media
- Magnetic properties of ferro-magnetic materials undergoing dynamic stressing
- A new D-C permeameter.

Included also for convenience and information are Methods of Testing Magnetic Materials (A 34) and Definitions of Terms, with Symbols, Relating to Magnetic Testing (A 127).

Copies of this 220-page symposium, April, 1949, can be procured by the members at $1.85, the list price being $2.50, in paper cover; also available in cloth cover at $2.50 to members and $3.15 list.

Metallography in Color—STP 86:

This outstanding symposium held at the 1948 A.S.T.M. Annual Meeting presents the latest thoughts and practices in this field in which there is a steadily growing interest. Leading authorities prepared the papers and there was discussion of the various techniques used to record the characteristic colors seen visually. The book is to be illustrated with numerous four-color process photomicrographs. Subjects covered include the following: Microscope Optics for Color Metallography, James K. Benford; Quality and Quantity of Illumination in Metallography, R. P. Loveland; Color Metallography Simplified, Mason Clogg, Jr.; Some Applications of Color Metallography, W. D. Forgeng; Application of Color Photography to the Study of Nonmetallic Inclusions, A. M. Hall and E. E. Fletcher; also given is the 1944 Loveland paper with its color illustrations. The publication is sponsored by A.S.T.M. Committee E-4 on Metallography through its Subcommittee IV on Photography.

Copies of this 72-page symposium, including color insert plates, June, 1949, can be purchased by the member in paper cover at $3.40, the list price being $4.50; also available in cloth cover at $4.05 and $5.15, respectively.

Deformation of Metals as Related to Forming and Service—STP 87:

This symposium with five technical papers and discussion was presented at the 1948 Annual Meeting. The last few years have witnessed a rapidly accelerating rate of accomplishment in the approaches to a more rational and fundamental concept of metal flow and fracture. These approaches vary from the more academic hypothesis and theories of the physical metallurgist and physicist to the works metallurgist in his laboratory and plant. The papers included cover tests of ductility in ship structure; notch sensitivity in ship-plate correlation of laboratory scale tests with large scale plate tests; measurement of ductility in sheet metals; hydraulic bulge testing of sheet metals; and notch bar tension tests on annealed carbon steel specimens of various sizes and contours.

This 126-page publication, April, 1949, is available in paper cover to members at $1.50, the list price being $2 per copy.

Industrial Gear Oils—STP 88:

Sponsored by Committee D-2 on Petroleum Products and Lubricants, this symposium, held at the 1948 meetings of this group in Detroit, includes papers covering the following: Heavy Duty Gear Oils by E. M. Kipp, I. S. Kolarik, and C. A. Zeiler of the Research Laboratories of the Aluminum Company of America; Gear Lubricants Used in Steel Plants by John F. Pelly, Lubrication Engineer, Bethlehem Steel Co., Bethlehem, Pa.; and Gear Set Servicing by the Cathode Ray Oscilloscope by A. R. Purdy and J. H. Goffe, Socony Vacuum Oil Co.

This symposium, May, 1949, contains 24 pages. The members' price is 60 cents, the list price being 75 cents per copy.

Publication on Ultrasonics

COPIES of the Round-Table Discussion on Ultrasonic Testing held at the 1948 Annual Meeting of the A.S.T.M. and sponsored by Committee E-7 on Non-Destructive Testing are now available. Sixteen outstanding authorities contributed to the informal discussion representing, among others, the following companies:

General Motors Corp.
Sperry Products Co.
Magnaflux Co.
Doehler-Jarvis Co.
Westinghouse Electric Corp.
Hydro-Electric Power Commission of Ontario
Republic Steel Corp.
Babcock and Wilcox Co.
Ohio Steel Foundries
Heppenstall Co.
Atcheson, Topeka & Santa Fe Railway System

In view of the informal nature of the discussion, it has been duplicated by the multilith process, page size 8½ by 11 in., and comprises 23 pages. Copies are available at the nominal price of fifty cents.

Wanted—1942 Proceedings

THE entire edition of the 1942 *Proceedings*, Vol. 42, has been exhausted and with continuing orders for this book, it is desirable to have at least a few copies in stock. It would be appreciated if any members or others who wish to dispose of their copies would contact the Society's Treasurer at A.S.T.M. Headquarters so that he may arrange to purchase the book..

Index to A.S.T.M. Standards

THE combined Index to the 1946 Book of A.S.T.M. Standards and 1947 and 1948 Supplements has become available and a copy has been mailed to each A.S.T.M. member and committee member.

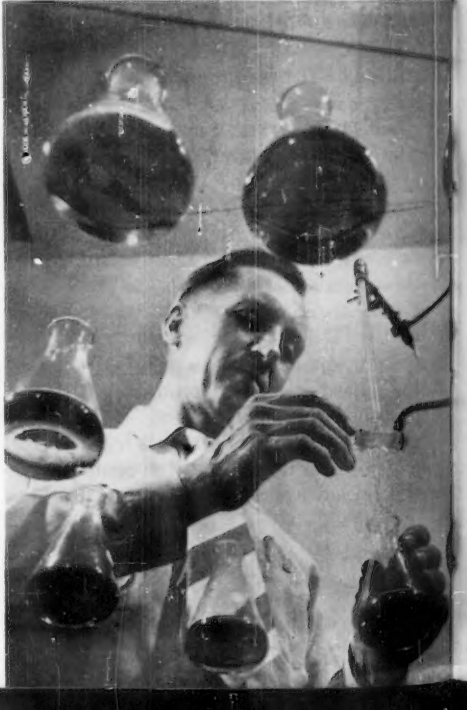
This Index is a decided convenience since it covers *all* five Parts of the Book of Standards and Supplements. The main portion of the Index lists the specifications under appropriate key words, but use is made of convenient cross references so that the material will be as concise as possible. Under each key heading an effort is made to select the most significant word in the title of the specifications so that there is some alphabetical sequence.

A most valuable part of the Index is the list of standards in numeric order of their serial designations, and in these lists, too, reference is made to the official source of latest publications.

Distribution of the Index.—In addition to each A.S.T.M. member and committee member, a copy is furnished to all members or nonmembers who *purchase* any parts of the book.

The Index is distributed on request, and several thousand purchasing agents and others who are concerned with A.S.T.M. standards get the publication regularly. Some organizations get several copies to distribute to their key technical people.

We recommend that this Index be placed convenient to the Book of A.S.T.M. Standards. Its use may save much time in locating any particular items.



Unusual Photograph Showing Use of A.S.T.M. Test in Determining Percentage of Sulfur in Gasoline

Photograph Courtesy "Ethyl News"

Paper on A.S.T.M. at Structural Clay Products Conference

ONE of the papers presented during a Structural Clay Products Conference held at North Carolina State College, Raleigh, was entitled "Value of A.S.T.M. to Industry." This address was given by Mr. John H. Isenhour, President, Isenhour Brick and Tile Co., Salisbury, N. C. Mr. Isenhour is an active member of Committee C-15 on Manufactured Masonry Units and serves on its Subcommittee on Structural Clay Tile.

In his discussion Mr. Isenhour described the purposes and work of A.S.-T.M. and mentioned its application to the products with which his industry was particularly concerned. The A.S.-T.M. standards cover various physical characteristics and size and dimensions of finished products and tie in with the practicability of manufacture. He described how the groundwork is laid in a subcommittee where data are developed and studied before recommendations are made. He pointed out that standards of quality are beneficial to both manufacturer and user and that they promote a better and wider knowledge of properties and utilities of clay products. Furthermore, continuing work on specifications and tests tends to improve the quality of materials covered and enhance their prestige.

This conference, sponsored by the North Carolina State College, together with Brick and Tile Service, Inc., and Southern Brick and Tile Manufacturers Assn., led to the foundation of a Clay Products Research Institute. A project is to be directed in the Department of Engineering Research at North Carolina State. During the conference and inspection of projects under way in the department, a demonstration was given, including the A.S.T.M. fire-resistance tests on structural clay products. One of the subjects discussed was "College Research and Industrial Development," by W. G. Van Note, Director, Department of Engineering Research, Mr. Van Note being the A.S.T.M. representative of this membership in the Society.

A.S.T.M. Standards in Housing Requirements

THE Federal Housing Administration "Minimum Property Requirements for Properties of One or Two Living Units" set forth minimum planning and construction requirements to apply to a residential property, including the land and all improvements thereon, which is offered or proposed to be offered to the Federal Housing Administration as security for an insured mortgage loan. Requirements on the materials to be used are based on nationally recognized standards and the following A.S.T.M. specifications and tests are referred to:

MATERIAL	A.S.T.M. SPECIFICATION NUMBER
Aggregates,	
Concrete	C 33
Lightweight	C 130
Masonry Mortar	C 144
Brick, building,	
Clay or Shale	C 62
Concrete	C 55
Sand Lime	C 73
Fireclay	C 27
Cements,	
Keene's	C 61
Portland	C 9
Masonry	C 91
Concrete Block, hollow,	
Load-bearing	C 90
Non-load-bearing	C 129
Solid, Load-bearing	C 145
Fire-clay, Ground, as Mortar for Laying-Up Fire-clay Brick	C 105
Lath, Gypsum Board	C 37
Lime,	
Quick	C 5
Hydrated	C 6
Pipe,	
Cast Iron	A 142
Clay Sewer	C 13
Extra Strength Clay	C 200
Wrought Iron	A 72
Brass	B 43
Copper	B 42
Plaster	
Gypsum	C 28
Gypsum Wall Board	C 36
Roofing, Asphalt-Saturated	D 226
Sheathing Board, Gypsum	C 79
Sheet Metal, Galvanized	A 93
Shingles, Asphalt, mineral-surfaced	D 225
Slag	C 33
Steel,	
Reinforcing	A 15
Reinforcing	A 16
Structural	A 7
Tile,	
Drain	C 4
Load-bearing Clay	C 34
Non-Load-bearing Clay	C 56
Wallboard, Gypsum	C 36
Zinc	B 69

Clark Thread Co. Fellowships

THE Clark Thread Co. has made available three Fellowships for graduate study and research in the field of textile technology at the Massachusetts Institute of Technology. Holders of bachelor's degrees in Chemical Engineering and other fields of engineering or science from approved schools are eligible. Each Fellowship carries an award of $1800 per academic year which will pay for tuition and a large share of living expenses. The awards are made on the basis of academic performance and professional promise and are offered to United States citizens and, on occasions, to those of Canada or Great Britain.

The purpose of these Fellowships is to encourage research and to stimulate an interest in technical training to supply the need for scientifically trained personnel for the thread industry of the United States.

Inquiries should be sent to: Dean of the Graduate School, Massachusetts Institute of Technology, Cambridge, Mass.

AAR Research Laboratory

CONSTRUCTION was started this week on the new Association of American Railroads research laboratory on the campus of Illinois Institute of Technology following award of the contract to Federal Constructors, Inc., general contractors, Chicago.

Completion of the building, which will serve as headquarters for the research and testing staffs of the mechanical and engineering divisions and the container bureau of AAR, is scheduled for the middle of November.

It will be located near the northwest corner of the projected 110-acre Illinois Tech campus development. It will run north and south along Federal St. between 31 and 32 Sts. An impact test track will be built along the New York Central tracks west of the building.

Its general design is in the modern functional style of Ludwig Mies van der Rohe, head of Illinois Tech's architecture department and designer of the new brick and glass buildings already constructed on the campus.

Precision Scientific Co. Award in Petroleum Chemistry

THE purpose of the Precision Scientific Co. Award of $1000, which includes a certificate, is to recognize, encourage, and stimulate outstanding research achievements in the field of petroleum chemistry in the United States and Canada. The Award is offered through the American Chemical Society.

A nominee must be a citizen of the United States or Canada, who shall not have passed his 40th birthday on April 30, 1950. He must have accomplished outstanding research either in petroleum chemistry itself or in some phase of fundamental science that contributes directly and materially to the knowledge of petroleum and its products.

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RACE STREET
PHILADELPHIA 3, PENNA.

"Prospecting" for A.S.T.M.; Current Membership Status

RECENTLY distributed to each member of the Society by the Membership Committee, headed by Everett G. Ham, who serves with four other members of the Board of Directors, was a return form entitled "Be a '49er—'Prospect' For Your A.S.T.M.!" The objective was to procure the names of individuals and companies and others who would undoubtedly find membership in the Society of benefit. Many of the members have furnished the names of business associates, friends, and others, and contacts will be made by the Membership Committee with those whose names have been furnished.

The Committee on Membership, which is one of the seven subdivisions of the Board of Directors, has a number of special projects under way designed to bring information about the Society to organizations and individuals who might be interested and to extend a cordial invitation to become affiliated with A.S.T.M.

Membership Important:

Increase in A.S.T.M. membership is extremely important for many reasons. Since each member is potentially a salesman for the Society, the more there are, the wider will become the knowledge and work of A.S.T.M. Considering the tremendous extent of the technical work of the Society in both research and standardization and the great amount of time and money devoted to our activities, it is desirable that the benefits be widespread. Particularly, it is desirable that the use of A.S.T.M. specifications and tests increase and a larger membership will aid in achieving this desirable end. It is not only considered essential that A.S.T.M. push its standardization work, but it must also aid in promoting a wider use of the standards.

Each organization and individual coming into the Society provides a certain type of knowledge and skill which may need to be tapped by some one or more of the technical committees, and with the passage of time and the lightening of their industrial loads by our older members, it is essential that there be younger men and aggressive organizations to give our work the dynamic force desirable.

In 1948, 38.6 cents of the Society's income dollar came from the dues of members, and the total income from dues was considerably greater than earlier, not only from more members but from increased dues which became effective January, 1948.

Obviously a greater membership means more financial support for the Society's extensive activities. To say that there is a continually pressing demand for expansion of A.S.T.M. work is a gross understatement.

Membership obviously can mean much to the individual or company in A.S.T.M. A very liberal policy in furnishing the *Proceedings*, the BULLETIN, Year Book, and Parts of the Book of Standards is a distinct asset of membership, and there are those intangible, but nevertheless significant points of *prestige, association with leading men and organizations in the materials field*, and the very *real satisfaction* from participating in and supporting work of essential value not only to the engineering profession and industry, but to Government as well.

The interest and close cooperation of the existing membership in obtaining new members is most important and the great help which has been given and continues is much appreciated by the Membership Committee and the Board of Directors.

Membership Statistics:

Here are a few data on membership:

Membership, December 31, 1947	6340
New members in 1948	623
Deaths, resignations, and losses	473
Net gain	150
Membership, December 31, 1948	6490
Membership as of March 31, 1949	6515

The above figures indicate that the net gain for the calendar year 1948 was 150 which is considerably lower than for any recent year. The number of new members was encouraging, but the loss was at a new high brought about, unquestionably, by the changing picture in industry, especially in certain fields.

The curve for new members so far this year, while not too encouraging, has taken a good upward trend for the month of April and it is hoped this will continue.

It is believed the Society has a great deal to offer individuals and companies concerned with its field of work, and there are a large number of such who are not members. The problem then is to bring to their attention in an appropriate way A.S.T.M. and its activities.

Schedule of A.S.T.M. Meetings

DATE	GROUP	PLACE
May 9–10	Board of Directors	(A.S.T.M. Headquarters)
May 9–10	Committee D-10 on Shipping Containers	Atlantic City, N. J.
May 10	Subcommittee V of Committee B-1 on Non-Ferrous Metals and Alloys	Pittsburgh, Pa.
May 18	Subcommittee on Printing Inks of Committee D-1 on Paint, Varnish, Lacquer, and Related Products	(A.S.T.M. Headquarters)
June 1	Technical Committee A of Committee D-11 on Rubber and Rubber-Like Materials	Detroit, Mich.
June 8–9	Committee B-4 on Electrical Heating, Resistance, and Related Alloys	New York, N. Y.
June 27–July 1	1949 ANNUAL MEETING	Atlantic City, N. J.
Sept. 22	Committee C-8 on Refractories	Bedford Springs, Pa.
October 10–14	1949 PACIFIC AREA MEETING	San Francisco, Calif.

District Meetings—Past and Future

Mechanical Properties of Metals; Industrial Stream Pollution; Major Sources of Energy; Light Metals and Alloys; Opacity of Porcelain Enamels

SEVERAL interesting and successful meetings have been sponsored by various A.S.T.M. Districts, and a few notes on some of these follow. Following the presentations by the speakers, each district arranges for a question and answer period, and frequently these are extremely enlightening. All of the speakers have been very gracious in responding to the questions with pertinent remarks.

West Coast Meetings:

President Richard L. Templin was the chief technical speaker at meetings sponsored by the Southern and Northern California Districts, the first in Los Angeles on Tuesday, March 15, and the other in San Francisco on March 25. While his theme at both meetings was the same, "The Determination and Significance of the Mechanical Properties of Metals," in the Northern California District he gave special emphasis to the viewpoint of the designer.

At each meeting, Executive Secretary C. L. Warwick was present, and discussed "Trends in Materials Testing and Research." Messrs. Templin and Warwick were on the Coast also in connection with the Pacific Area National Meeting to be held in San Francisco during the week of October 10. Further details are given elsewhere in this BULLETIN.

Mr. Templin in his talks emphasized the importance of details in determining the mechanical properties of metals, both in obtaining and reporting test data. He also stressed the standardization of tests to assist in effecting closer agreement in data from different sources and for the purpose of defining the variations in the metals being tested rather than the differences resulting from variations in testing procedure.

Some of the limitations of mechanical property data as used for different purposes and the dangers involved in undue extrapolation of data were discussed. Mr. Templin stated that better understanding of the data would be helpful in designing safer and more efficient structures.

In the Southern California District, arrangements for the meeting were handled by Messrs. C. E. Emmons, *Chairman*, The Texas Company, and H. W. Jewell, *Secretary* Pacific Clay Products, and in the Northern District by Messrs. Dozier Finley, *Chairman*, and P. V. Garin, *Secretary*, Southern Pacific Co.

At each place a dinner preceded the technical session.

Industrial Stream Pollution:

The Philadelphia District, in selecting this subject for its meeting, was conscious of the intense interest in the subject because of the problems in the Schuylkill River, and stream pollution in general throughout the state, but was also cognizant of the organization of an important new subcommittee in Committee D-19, this group to carry out research and standardization work on methods of analysis of water-borne industrial waste.

The two prominent speakers brought out a good audience of well over 200. First on the program, stating "The Problem," was Norris W. Vaux, M.D., Secretary of Health of Pennsylvania and Chairman of the State Sanitary Water Board. The second speaker, W. B. Hart, Service Supt., Atlantic Refining Co., and Chairman of the Pollution Abatement Committee of the Pennsylvania Chamber of Commerce, discussed "The Cure." He has had a wealth of experience in the field, particularly in connection with some of the problems of his company.

A limited number of copies of Dr. Vaux's talk are available from A.S.T.M. Headquarters and will be sent on request as long as they last. Mr. Hart's remarks also are available in the form of notes, and a copy of these notes can be procured without charge. It is believed that the local Chamber of Commerce is planning to make available Mr. Hart's complete paper. If it is available, notice will be sent to those who may be interested.

Dr. Vaux stressed particularly the remarkable job which has been done in the Schuylkill Water Shed. The installation in virtually all the major collieries which discharge into the Schuylkill of desilting plants has greatly clarified the stream, and intensive efforts are now being made to remove from the river much of the earlier deposits. A tremendous project is under way at Schuylkill Haven, and intensive work is progressing to deepen the Schuylkill in the Philadelphia area, which includes not only the removal of silt, but the control and treatment of sewage.

H. M. Hancock, Superintendent, Inspection Div., Atlantic Refining Co., arranged the technical program, and at the dinner preceding the meeting he gave an interesting talk on various aspects of petroleum.

At the technical session, District Chairman A. O. Schaefer introduced the Technical Chairman, L. Drew Betz, who introduced Dr. Vaux and Mr. Hart. Mr. Betz is the chairman of the new D-19 Subcommittee on Water-Borne Industrial Wastes.

Major Sources of Energy:

Mr. Eugene Ayres, Gulf Research and Development Co., was the speaker at two interesting meetings, the first in Rochester on March 10 and the second in New York on April 5, on the subject the "Major Sources of Energy." His remarks were essentially a condensation of his very comprehensive paper presented at the annual meeting of the American Petroleum Institute. The subject is an extremely interesting and pertinent one, and Mr. Ayres stressed the importance of getting the facts and pointed out that significant discrepancies occur in some of the prognostications.

The nine "continuous" sources of energy which he analyzed were as follows: solar energy, waterfalls, the earth's heat, vegetation, tropic waters, tides, atmospheric electricity, wind, and the heat pump.

The meeting in Rochester, sponsored by the Western New York-Ontario District, was arranged by District Vice-Chairman Leon V. Foster, Bausch & Lomb Optical Co., and in New York by Program Chairman J. G. Detwiler, The Texas Company. Dr. O. W. Ellis and Joseph Gentile, Chairman and Secretary respectively of the District, were present at the Rochester meeting. In New York, District Chairman Myron Park Davis presided.

Light Metals and Alloys:

The presence and participation in the program by three outstanding authorities in their fields made the meeting sponsored by the New England District in Cambridge at M.I.T. an intensely interesting one. President Templin gave a condensed version of his talk on Aluminum, followed by Dr. Bruce W. Gonser, of Battelle Memorial Institute, who reviewed some of the high points of Titanium, and Dr. John C. McDonald, Dow Chemical Co., discussed Magnesium Alloys and Applications. The audience of 100 was interested throughout. A number of pertinent questions were addressed to the speakers at the close of their presentation.

Each speaker presented significant data on the properties of these elements, their alloys, and indicated a number of important applications.

When it is considered that the potential source of supply of these metals is so much greater than for a number of our other metals, it is obvious that they will continue to receive much attention and grow in application.

Acting for the New England District, Program Chairman A. G. H. Dietz, Associate Professor, Massachusetts Institute of Technology, set up the session and arranged for the speakers.

A meeting of the District Council was held prior to the session at which action was taken to elect Miles N. Clair, District Vice-Chairman, to the office of Chairman which had been made vacant by the death of V. J. Altieri. Prof. E. A. Gramstorff, Northeastern University, was appointed Vice-Chairman, and Carlton G. Lutts, the efficient secretary, will continue in that office.

The chairman of the New England Committee on Promotion and Development, R. W. Chadbourn, Boston Edison Co., presented a short report on the activities of his group and indicated that a questionnaire will be distributed to all New England members and committee members, asking for their comments as a guide for district work.

Meetings to Come—Pittsburgh, St. Louis:

The Pittsburgh District is planning an A.S.T.M. Smoker on Wednesday evening, May 4, to be held at the University Club. This is a strictly social affair, new to A.S.T.M. districts. The principal objective is to afford an opportunity for the members of the district to meet their fellow A.S.T.M.ers and become acquainted with them. President Templin and Executive-Secretary Warwick will attend but there is no technical talk planned for the occasion. All A.S.T.M. members are invited, whether members of the Pittsburgh District or not.

Dr. Andrew I. Andrews, Professor of Ceramic Engineering at the University of Illinois, will be the speaker at a joint meeting in St. Louis with the American Ceramic Society, to be held at the York Hotel on Wednesday, May 11. Dr. Andrews will discuss "Opacity and Its Development in Porcelain Enamels." Following a fundamental discussion, Dr. Andrews will introduce methods for demonstrating this important property and then discuss the control of the development of the property and will include important data.

Preceding the technical session will be a dinner in honor of the speaker. Arrangements for this meeting are being taken care of by District Chairman J. C. Hostetter, Mississippi Glass Co., and District Secretary J. M. Wendling, City of St. Louis, Municipal Testing Lab., in close conjunction with the officers of the St. Louis Section of the American Ceramic Society.

Letter Ballot on Election of District Councilors

For each A.S.T.M. district there has been selected, through a Nominating Committee, nominees for office on the respective District Councils. These District nominating committees consist of two representatives from the current council and three other noncouncil members in the particular area. The election of the councilors is carried out by a letter ballot of the entire district membership and there will be sent, late in May, to the respective members and committee members in each area, a ballot which they should return to the various secretaries. Each district has a separate ballot, and provision is made on it for writing in additional names other than those proposed by the Nominating Committee.

This year there is no election for District Chairman, Vice-Chairmen and Secretary, those terms carrying through 1950.

Terms of office of the councilors are, for the most part, on a two-year basis, although in certain districts some of the terms are being limited to one year in order to arrange for better balance of expiration of terms.

The respective secretaries canvass the ballots late in June and report the results to the Board of Directors through the Administrative Committee on District Activities.

All ballots will be mailed out from A.S.T.M. Headquarters.

TECHNICAL COMMITTEE NOTES

Color Transparency Standards for the Visual Classification of Natural Muscovite Block Mica Now Available

The art of visually classifying natural muscovite block mica into various quality grades has been practiced for many years in the mica industry. A rough correlation between physical and electrical properties and visual imperfections found in mica block has been established based on years of experience and practice, and the India Grading System has been devised to serve as a guide for classifying mica in accordance with visually perceptible impurities and imperfections. However, the techniques and methods used for examining block mica to determine its classification according to the India Grading System have long been a serious problem to miners, importers, fabricators, and users of high-grade mica, since they depend mainly on inadequate verbal descriptions and personal judgment. Even experts in the field too frequently disagree on the

classification of mica block using the methods now at their disposal.

As a result, no universal visual standard mica quality has ever been agreed upon and established up to this time. Considerable confusion has existed in the minds of those responsible for purchasing, fabricating, and using mica concerning the correct classification to specify for their particular needs. Currently, many large users of mica have been required to assign an engineer, who has been specially trained, to this field; whereas smaller users must depend entirely on the judgment of their suppliers.

Because of this lack of a universal visual standard, users have often purchased higher and correspondingly more expensive grades than actually necessary to insure the quality of all their mica receivals. This practice has resulted in the wastage of high-quality mica, which in critical times could be diverted to more strategic usage. Disagreements which occur between suppliers of mica in India and Brazil and importers in this country have entailed considerable monetary risks annually, and have caused further mica wastage in many uses.

Realizing the urgent need for universal standardization acceptable to all concerned, A.S.T.M. Committee D-9 on Electrical Insulating Materials, in cooperation with the Mica Fabricators' Association of New York, has established visual photographic color transparencies for the classification of block mica used in American industry. The standards consist of one 8 by 10-in. original color transparency for each classification of mica.

These color transparencies illustrate the maximum, nominal, and minimum imperfections allowed in each case. The ten classifications selected as being representative of the mica used by the trade are:

1. Clear
2. Clear and Slightly Stained
3. Fair Stained
4. Good Stained
5. Ruby Stained—A Quality
6. Ruby Stained—B Quality
7. Speckled
8. Heavy Stained
9. Black Spotted
10. Black Stained

These classifications apply to mica between thicknesses of 0.007 to 0.020 in. for qualities, irrespective of basic color.

The establishment of these standards has removed for the first time in the history of the mica industry the classification of mica block from the category of verbal description and personal judgment, and their use will prove to be economically advantageous in buying and selling mica. Considerable effort and extreme care have been expended by recognized authorities in the mica field in the selection of specimens of block mica used in the color transparencies. The selected specimens were photographed, utilizing a combination of transmitted and reflected light to emphasize minute color differences in the various mineral imperfections, as well as the extent of air inclusions. To assure a high degree of perfection, uniformity, and facsimile, all sets of transparencies are photographed individually under standardized studio conditions.

For viewing these standards and comparing them with samples to be classified, a viewing box with ground glass surface is used as the source of transmitted light, and a 15-watt fluorescent light is used to provide the reflected light.

The price of $150 has been established for a set of the ten color transparencies, packed in light-tight envelopes, conveniently boxed with a copy of the A.S.T.M. Specifications for Natural Muscovite Mica Based on Visual Quality (D 351). The viewing box and light may be purchased separately at an additional cost of approximately $45 and $15, respectively. The prices of these two items may vary slightly depending on market conditions.

Orders may be made out to the American Society for Testing Materials for the desired number of sets of the mica color transparencies at $150 each. To expedite delivery, such orders should be mailed to: *B. A. Gerpheide, Chairman,* Section on Natural Mica, Subcommittee IX, A.S.T.M. Committee D-9, c/o Western Electric Co., 100 Central Ave., Kearny, N. J.

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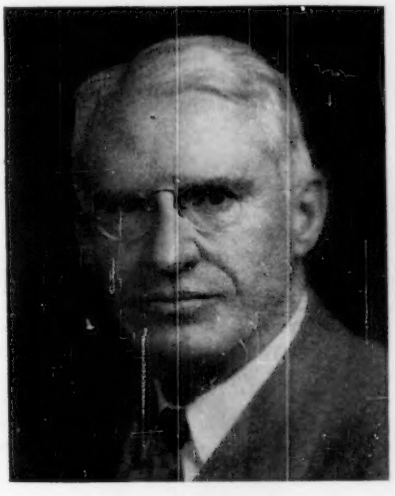

District Speakers, l. to r.: Norris W. Vaux, M.D., Secretary of Health of Pennsylvania; John C. McDonald, Dow Chemical Co.; Bruce W. Gonser, Battelle Memorial Institute; and W. B. Hart, Service Superintendent, The Atlantic Refining Co.

Eugene Ayres, Gulf Research and Development Co.

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Committee B-1 on Wires for Electrical Conductors

Committee B-1 on Wires for Electrical Conductors and several of its subcommittees met at the Hotel Statler in New York on April 13 and 14 and, subject to letter-ballot action, made recommendations on a large number of the committee specifications and reported progress on other assignments on which the committee has been working.

Of particular interest is the large number of specifications which the committee voted to advance to standard from tentative. Among these are the following:

Specifications for:

Concentric-Lay Stranded Copper Conductors (B 8 – 48 T),
Soft Rectangular and Square Bare Copper Wire (B 48 – 48 T),
Cored, Annular, Concentric-Lay-Stranded Copper Conductors (B 226 – 48 T),
Hard-Drawn Copper Covered Steel Wire (B 227 – 48 T),
Concentric-Lay-Stranded Copper Covered Steel Conductors (B 228 – 48 T),
Concentric-Lay-Stranded Copper and Copper Covered Steel Composite Conductors (B 229 – 48 T),
Concentric-Lay-Stranded Aluminum Conductors (B 231 – 48 T),
Rolled Aluminum Rods (EC Grade) for Electrical Purposes (B 233 – 48 T), and

Method of Test for:

Resistivity (B 193 – 48 T).

In addition, the tentative revisions of the three trolley wire specifications, Bronze Wire (B 9), Copper Wire (B 47), and Fig. 8 Wire (B 116), which were adopted last year, will be incorporated into the standards this year. In a number of instances, there are minor revisions of some of the above-mentioned specifications included in the recommendations.

The committee decided to discharge its present Subcommittee III on Rods and distribute its activities with regard to various rod specifications to the appropriate wire subcommittees.

In Subcommittee II on Methods of Test and Sampling a task group is engaged in writing a suitable sampling procedure for B-1 Specifications and has prepared a preliminary draft based on statistical methods as developed by Committee E-11. Extended trials now are in progress in the plants of a number of the producer members. When completed, this investigation probably can be the basis of a technical paper.

Subcommittee IV on Conductors of Copper and Copper Alloys has a task group which has started the preparation of a specification for the conductors of segmental-type, single-conductor cable in sizes up to, and including, 4,000,000 cm.

The task group which prepared the recent revision of the trolley wire specifications is now quite active in the design of a suitable standard gage, ultimately to replace the slip fitting presently authorized for inspection. Another task group, working on adequacy of methods of determination of weights, areas, and resistivities in all B-1 Specifications, has completed its work.

Also in Subcommittee IV, a task group on revision of significant figures in all tables of wire sizes has deferred work on this project, awaiting information from the National Bureau of Standards on the basis of calculation which will be used in the forthcoming revision of Circular No. 31. The bases to be used for electrical resistance values cannot be established until agreement is reached in the International Electrotechnical Commission on how to treat the value of the ohm. In this connection, a special task group of Committee B-1 was appointed during the year to consult with N.B.S. on the revision of Circular No. 31. As a result of meetings and considerable correspondence, a report was prepared, incorporating a number of recommendations for consideration by N.B.S. in revising Circular No. 31. This report was transmitted to N.B.S. in March, 1949.

Subcommittee V on Conductors of Ferrous Metals did not meet with the group in New York but is scheduled to meet in Pittsburgh on May 10, at which time the principal item of business will be consideration of proposed requirements for steel wire for use in the cores of steel-reinforced, aluminum conductors.

Committee B-4 on Electrical Heating, Resistance and Related Alloys

COMMITTEE B-4 on Electrical Heating, Resistance and Related Alloys met at A.S.T.M. Headquarters in Philadelphia on March 2 and 3 and advanced the program of work that is being carried on in a number of lines.

The committee voted to advance to standard three tentative methods covering: Diameter by Weighing of Fine Wire Used in Electronic Devices and Lamps (B 205 – 45 T), Life Test of Electrical Contact Materials (B 182 – 46 T), and Resistivity of Metallically Conducting Resistance and Contact Materials (B 63 – 48 T). Proposed new Tentative Specifications for Circular Nickel Cathode Sleeves for Electronic Devices were completed as was a Recommended Practice for Cathode Melt Prove-in Testing; the latter already approved by A.S.T.M. has been designated B 238 – 49 T.

The Subcommittee on Wrought and Cast Alloys for High-Temperature Uses is running three series of tests in the standard A.S.T.M. atmosphere test furnace, and the data being recorded will include the maximum penetration of oxygen and the maximum depth of scale. Formation of carbides and grain boundary attack will also be reported.

The Subcommittee on Thermostat Metals is considering writing specifications for invar and is studying various methods of determining thermal expansion, such as the interferometer, steam and water jacket test method, and the use of automatic recorder.

The Subcommittee on Radio Tubes has formed a new section to work on a proposed test method for tungsten wire. Fine wire testing and particle size determination are other subjects currently receiving the attention of this subcommittee.

The Cathode Section continues its active work, having completed the Specification for Cathode Sleeves and the Recommended Practice for Prove-in Testing, actions on both of which were noted above. It is now working on the development of a measuring tool more versatile than the diode, and the study of the reduction potential for cathode materials. A proposed Recommended Practice for the Method of Application of Cathode Coating for the Standard Diode Test is about completed and is to be included in the Diode Test being prepared by the Diode Section.

One of the most urgent problems facing the committee at the present time is that of developing methods of analysis of nickel that will be applicable to very small samples. In this work Committee E-3 is cooperating and an initial outline of the problem has been prepared and steps are being taken to get the work under way. One of the very special problems in this work is that of the determination of oxygen in nickel.

The Subcommittee on Tests in Controlled Atmospheres continues its study of "green rot" and is currently running tests on 35–15 nickel-chromium alloy. Of great interest to the subcommittee was a report on work in England by the Mond Nickel Company, which seems to indicate that their experience has produced data quite contradictory to the information obtained by Committee B-4 in this country.

The Subcommittee on Contact Materials continues its study of the test for surety of making a circuit and is preparing a method of test to be followed to get better coordination of data from the various cooperating laboratories. The section working on the standardization of contact forms and sizes is now engaged in revising and simplifying the Standardization of the Shape and Size of Electrical Contacts, which was published in the December, 1944, BULLETIN on page 37.

Committee B-5 on Copper and Copper Alloys, Cast and Wrought

ONE of the principal features of the meeting of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, which met with its subcommittees in Washington on March 9, 10, and 11, was the presentation of a paper on Magnetism in Copper Alloys: The Effect of Iron as an Impurity, by Allison Butts and Paul L. Reiber, Jr. This paper gave very useful data to the committee, based on work which the authors had carried out at Lehigh University for the Ordnance Dept. during the war. There are many applications of copper and copper-base alloys in radar and similar uses where the material must be entirely free of any magnetic effects, and the data will be very useful in developing specifications for material for such uses.

Many important recommendations on standards were made at the meeting and will be submitted in the committee report after letter ballot. Among these actions were recommendations regarding the application of the significance of numerical limits in accordance with A.S.T.M. Recommended Practice E 29; the adoption of sampling procedures for chemical analysis in the wrought specifications, as worked out in conjunction with Committee E-3 on Chemical Analysis of Metals applying that committee's Method E 55; a general revision of specifications to unify and rationalize the chemical composition for the alloys in the various types of products which the committee covers, and the general adoption of the designation "alloy" to replace the words "type," "grade," "class," etc.

The Subcommittee on Castings and Ingots for Remelting completed the revision of the Recommended Practice for Test Bars (B 208) on which a special task group has been working for the past two years. A feature of this revision is that it will include details for gates and risers for the test bars.

Other minor revisions were made in a number of the specifications, and the committee also moved to add to its By-laws a provision for appropriate technical and commercial substantiating data to be supplied when any new standard or revision of an existing standard is proposed.

Meeting of Soap Committee—D-12

COMMITTEE D-12 on Soaps and Other Detergents held its annual meeting on March 22 and 23 at the Hotel Park Sheraton in New York City. In addition to an active schedule of meetings of the subcommittees and main committee, the program was highlighted by papers on metal cleaners and on standard soiled cloths for evaluating detergency.

The paper on "Metal Cleaning and Soil Detection Using Radioactive Compounds," by J. C. Harris, is published elsewhere in this BULLETIN. No publication of the other papers on metal cleaners is contemplated.

The group of papers on standard soiled cloths for evaluating detergency presented an outstanding opportunity for the exchange of information on this subject. Although certain speakers and discussers commented on the extreme difficulty of obtaining truly significant and reproducible results from any test for evaluating detergency when applied to a variety of materials and conditions, it was evident that much progress is being made in the development of standard soiled cloths as a really helpful aid in evaluating similar detergents under comparable conditions. None of the papers on standard soiled clothes is planned for publication, this

group of papers being intended primarily for exchange of information and stimulation of interest, which aims were well achieved.

There was also considerable discussion of the various types of small-scale washing devices such as the "Launderometer" and the more recently developed "Terg-o-tometer." The point of greatest interest was the correlation of results by these small-scale tests with tests in actual washing machines, with particular emphasis on the method of agitation. In the "Launderometer" steel balls are placed in glass jars with the samples and rotated, while the "Terg-o-tometer" uses a miniature agitator of the type used in many domestic washing machines. The relative merits of these types were considered.

British Commonwealth Timber Mechanics Conference

AN IMPORTANT step in the field of timber mechanics was taken when representatives of six British Empire countries and the United States gathered for the first time for four weeks of conferences aimed at the standardization of methods of research. The sessions were started at the Canadian Forest Products Laboratory in Ottawa, Canada, on September 27, 1948, where they continued for two weeks. Specialists from the U. S. Forest Products Laboratory were invited to participate and in turn invited the British Commonwealth delegates to visit the Laboratory in Madison, Wis. After two weeks of meetings in Ottawa, the conference was adjourned and resumed again for another two weeks in Madison.

Among the wide variety of subjects discussed at the Conference were size of specimens for standard tests of wood; standard methods of sampling wood for tests and of conducting tests; improved equipment and auxiliary devices to obtain best results and to curtail costs; methods of testing structural timber and of deriving suitable working stresses for structural design; the grading of structural timber; the fabrication of timber structures with special emphasis on laminated timber construction; the testing of fiberboard and plywood, and many other related subjects. A.S.T.M. Standards D143 and D198 were used as a guide.

The Conference was very important in bringing out different points of view and in reaching agreement on many methods of procedure. It was also valuable in indicating many matters on which further investigation is required before definite conclusions can be reached.

Committee D-13 Cooperating with NRC Quartermaster Group on Textile Specifications

ON INVITATION of the Subcommittee on Fibers and Fabrics of the Committee on Quartermaster Problems, National Research Council, the Society has formed a small group to advise on problems concerned with the improvement of sampling and acceptance sections of the Federal and Army textile specifications. The research and development specification writers of the Office of the Quartermaster General are not satisfied with the provisions for sampling acceptance in present textile specifications and have indicated the need for more precise specifications with respect to sampling, number of tests, and interpretation with respect to acceptance.

This advisory group has been set up under the auspices of Committee D-13 on Textile Materials. Its members include O. P. Beckwith, Alexander Smith & Sons Carpet Co., as Chairman; Churchill Eisenhart, National Bureau of Standards; Stanley Backer, Philadelphia Quartermaster Depot; Gerald Winston, Philadelphia Quartermaster Depot; and David H. Schwartz, Inspection Service, Quartermaster Corps.

The group has already held two meetings at which substantial progress on the assigned problems has been made, including the development of a draft for a suggested form for general specifications for textile test methods, applicable to the particular requirements of the procurement agencies of the Government.

Committee on Mechanical Wood Technology Meets in Switzerland

THE Subcommittee on Mechanical Wood Technology, functioning as part of the Food and Agricultural Organization, held an important meeting at the Palace of Nations at Geneva, Switzerland, June 8 to 12, 1948, at which The U. S. Forest Products Laboratory was represented by its Assistant Director, L. J. Markwardt, A.S.T.M. Vice-President.

Originally, the Agenda of the meeting called for a discussion and consideration of three broad problems of international interest in the field of forest products as follows:

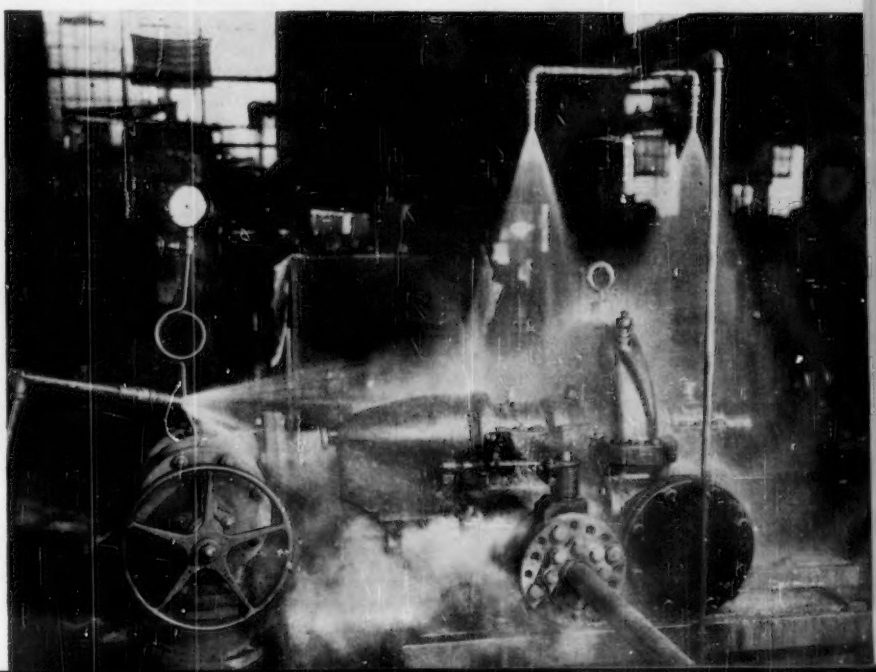
1. International Standardization of Methods for Testing Small Clear Specimens.
2. Wood Utilization Studies.
3. Combined Forestry and Utilization Problems relating to the development of forest resources.

However, due to factors involved in time and detail, only item 1 on the Agenda was covered.

The deliberations on International

Another Type of Simulated Service Test—A Turbine Subjected to a 24-Hour Spray

Photograph Courtesy "Westinghouse Engineer"



Standardization of Methods of Testing Small Clear Specimens included (*a*) a discussion of the general underlying principles; (*b*) consideration of detailed procedures for five principal tests, namely, compression parallel to grain, tension parallel to grain, shear parallel to grain, static bending, and impact bending; (*c*) review of a second group of tests comprising tension perpendicular to grain, compression perpendicular to grain, cleavage, and hardness; and (*d*) a report on the standardization of methods of testing fiberboards.

The committee adopted a number of resolutions covering the question of preferred sizes for test material and various detailed requirements for the compression parallel to grain test, static bending, and the impact bending test.

A draft report was presented also to the committee summarizing certain present and recommended practices relating to tests of structural fiberboards, this draft incorporating the results of some recent research studies relating to size and form of specimen and testing speeds.

In order to carry forward still further the work of the subcommittee with respect to methods of testing, specific assignments were made for a number of special studies to receive future subcommittee consideration.

The conference, which was well attended by 14 representatives from 13 countries, was under the chairmanship of Jean Campredon, Conservator of Water and Forests of France, and was conducted under the direction of D. Roy Cameron, F.A.O. Chief of the Forestry Working Group at the Palais des Nations, Geneva.

Accelerated Aging Tests Devised and Combined to Simulate Use of Fabrics

A NUMBER of accelerated aging tests to determine more accurately in the laboratory what is likely to happen to rayon fabrics in use have been devised at the Ellen H. Richards Institute of The Pennsylvania State College under the direction of Pauline Berry Mack. Research which is continuing, has been in progress six years under grants-in-aid from the American Viscose Corp.

Studies have shown that many of the tests now used, particularly those for color-fastness to light, for laundering and for perspiration, give results better than those obtained with the fabrics in use. In general, many of the tests pick out accurately only the poorest fabrics, making little distinction among the fair, the good, and the excellent.

Research also has shown that when a fabric is subjected alternately or simultaneously to more than one wear factor its performance is different from that obtained when only one is involved. As a result, various of the tests are being combined in a continuing effort to simulate as nearly as possible the conditions of actual use.

For example, it was found that the dye in a fabric subjected only to gas fading often showed little effect, but that if the fabric were pressed afterwards there was sometimes a considerable change in color. Similarly, abrasion makes fabrics more susceptible both to light and laundry fading than is the case with the same fabrics when not abraded.

In each case wearing tests with representative rayon fabrics are run parallel with the development of the new laboratory tests as a check on their accuracy. Technical reports of the studies are published as phases of the work are completed.

Fading was speeded up by building cabinets in which oxygen can replace some of the air, while temperature and humidity can be varied at the same time that the fabric is subjected to light. This gives, within a practicable period of time, results comparable to those during prolonged use.

Two accelerated heat tests have been developed one of which simulates dry and the other steam pressing. Similarly, an accelerated laundering procedure has been devised with various combinations of temperature, detergent concentration, alkalinity, and mechanical action.

Existing perspiration tests have been modified to obtain results more nearly comparable to those obtained during wear.

A technique for measuring the resistance of a rayon fabric to abrasion, one of the most important factors involved in the breakdown of wearing apparel goods, has been standardized.

A faster test for dry and wet cleaning has also been standardized, and work is proceeding on standardizing accelerated tests of gas fading and chlorine retention characteristics of finishes.

As fast as individual tests are standardized, they are tried out in combinations with tests of other characteristics as the Institute continues to try to develop an accelerated procedure which reflects as closely as possible the results of consumer use.

Naval Ordnance Laboratory—White Oak

WHITE OAK—938 acres of rolling Maryland countryside 12 miles north of Washington, D. C.—is one of the Navy Bureau of Ordnance's newest research centers. Congress appropriated $15,000,000 to get it started, with more likely to be voted later.

Over 2300 employees are using more than $20,000,000 worth of new scientific equipment on a hundred or more research programs in torpedoes, mine fuses, rockets, supersonic projectiles, depth charges, ammunition, and pyrotechnics. "We investigate anything that makes a noise or wiggles above or below water" one of the laboratory's scientists pointed out.

Admiral Beatty explained the reason for the new laboratory: "Since most ordnance has little or no industrial use, the Navy finds it necessary to conduct its own research, development, and testing. In peacetime, you can't farm out a magnetic mine or a torpedo to an automobile manufacturer or a university."

The Naval Ordnance Laboratory came into existence officially in 1929, when a joint committee from the Bureau of Ordnance and the Washington Navy Yard (now the Naval Gun Factory) decided to combine the Yard's Mine Laboratory and Explosives Laboratory under that title.

During World War II the need for a separate Naval Ordnance Laboratory became apparent, and in 1945 ground was first broken at White Oak. More than 60 permanent buildings are now contained on the NOL grounds, with 34 temporary structures in use and nine more permanent buildings under construction.

White Oak is an outstanding example of a military-civilian team at work. The administrative side of the laboratory consists of a small group of naval officers with seagoing experience, under the command of Admiral Beatty. A graduate of Annapolis, with a mechanical engineering degree from M.I.T. he won his blue-and-white Navy cross as the skipper of the cruiser *Columbia* during the chips-down fighting in the South Pacific. The civilian research and development work

is directed by Dr. Ralph Bennett, an expert on mine warfare.

As planned, White Oak is a "dream" laboratory—designed after consultation with scores of U. S. scientists. It will ultimately consist of approximately 70 permanent buildings all fitted with prefabricated, movable partitions so that laboratories and offices of any size may be created. They will be fireproof, air-conditioned, provided with fluorescent lighting, and connected by pedestrian tunnels. Laboratory areas will be supplied with voltages of different values, compressed air, gas, steam, hot and cold water. A model shop is equipped to do all but the heaviest kind of machine work.

The first group of buildings to be completed at White Oak was the Magnetics Group. These seven buildings are as free from magnetism as science can make them. They were built in an area isolated from minor disturbing influences such as other buildings and vehicles. Iron and steel have been entirely eliminated. Nails are copper, light switches are porcelain, drains are transite, building beams are wood. Even the sand that went into the bricks was screened to make certain it did not contain minute particles of iron oxide. The buildings are equipped with coils of varying size through which electric current can be sent from a master control panel. The purpose is to duplicate terrestrial magnetic fields under any sort of ship, at any speed, in any part of the world

Perhaps the most famous of all White Oak facilities are the supersonic wind tunnels—the modernized counterparts of the tunnels in which German scientists developed the V-2 rocket. Operated at Peenemunde and later, Kochel, Bavaria, they were captured in 1945 by advancing American troops and subsequently transplanted to NOL, where they have been modernized and reconstructed. Supersonic speeds are achieved in the tunnels by using a vacuum system; a huge steel sphere, 52 ft. in diameter, is evacuated, then air is allowed to rush back in through an expansion nozzle. The size and shape of this nozzle regulate the speed of air in the 16-in. square working section where the model is fixed. Air flow around this model is photographed by the schlieren and interferometer methods and photographs are studied for results. Recently in these tunnels, the Mach number of 5.18 (or 5.18 times the speed of sound) was achieved—the highest speed ever attained in a tunnel of this size.

A view from the front entrance to the Naval Ordnance Laboratory, White Oak, Md., showing the main laboratories and the Administration Building which consists of five large wings. This group of buildings was dedicated at special ceremonies on January 31, 1949.

One of the most interesting installations at White Oak is the X-ray Laboratory. The newest instrument to be installed is the world's first mobile betatron, a 10-million-volt X-ray generator whose rays are capable of penetrating 16 in. of steel.

The massive betatron, first industrial machine whose rays will penetrate steel thicker than 12 in., is unique in that it may be aimed in any direction, whereas all other betatrons, cyclotrons, and similar nuclear research equipment of this type are held in a fixed position. It will be used at White Oak principally for studying the complex internal assemblies of mines, torpedoes, and other items of Naval ordnance.

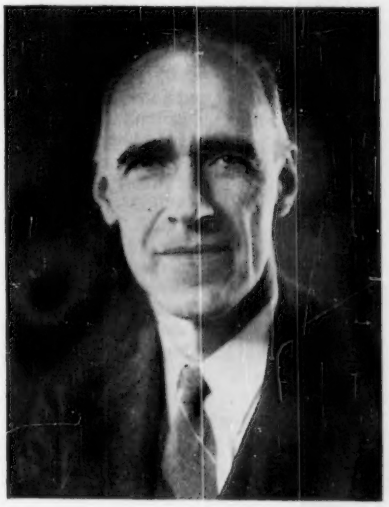
The machine will also afford the Naval Ordnance Laboratory sharp, clear internal pictures of thick sections of steel such as castings, welds, and armor plates. These pictures will reveal defects such as cracks, blowholes, and other flaws which cannot be detected by any other means.

The betatron consists of a powerful electromagnet weighing approximately two and one-half tons. This magnet surrounds a doughnut-shaped glass vacuum tube in which electrons are accelerated and made to produce X-rays by striking a tungsten "target." The unit is compactly housed in a steel casing 4½ by 4 by 2½ ft. Portable with the use of a crane, the entire unit weighs approximately 5500 pounds.

Engineers who built the betatron state it can take an X-ray picture of an inch-thick piece of steel in one second—almost as fast as a conventional camera takes a picture of its surface. Its rays can penetrate a foot-thick piece of steel in a matter of minutes as compared with hours for a conventional X-ray machine. Betatrons with higher energies have been built, and are invaluable in the field of nuclear research, but they are not so well suited to industrial problems. For example, their beams are too narrow for use at close range.

The powerful X-ray machine is installed in the laboratory at White Oak in such a way that its rays will be dissipated harmlessly. An enclosed courtyard immediately adjacent to the installations will be kept clear of personnel when the generators are in operation. A system of lights and sound signals will warn off anyone approaching the area at such a time, and should a door into the courtyard be opened, an automatic device will shut off the X-ray machine altogether.

The other three sides of the room in which the betatron is installed have walls



L. to r.: Rear Admiral Frank E. Beatty, Commander, Naval Ordnance Laboratory; Ralph O. Bennett, Technical Director, Naval Ordnance Laboratory; Leslie W. Ball, Chief, Naval Ordnance Laboratory, Mechanical Evaluation Division.

of reinforced concrete, three feet thick, to protect the personnel involved in operating the machines from possible injurious effects. The betatron will be operated from a control panel in the room next door, access to which is through a sliding lead door weighing nearly a ton.

The Ammunition Building is specially designed for the protection of personnel and instrumentation in case of accident. Incorporated in its construction are such features as sparkproof flooring, explosion-proof lighting fixtures and wiring, and solid interior walls with steel "blow out" type window frames so that in case of an explosion from within, little interior damage can be done, the blast blowing out through the weaker window spaces. The Ammunition Building was among the first of the permanent White Oak structures to be occupied by NOL scientists and engineers.

Although not yet completed, NOL's Mechanical Test Building holds promise of being one of the Navy's most unusual facilities. Since exterior work on the structure was finished late last Fall, installation of movable steel partitions and many unique testing devices has been under way. The building's facilities include a 105-ton hydrostatic pressure tank with a 70-ton hydraulically operated door. The huge cylinder is almost large enough to accommodate a Japanese one-man submarine. There will be testing rooms for atmospheric simultation where temperature and humidity can be controlled; a sea water tank 30 ft. long and 8 ft. wide, ranging in depth from 8 to 15 ft.; shock and vibration testing equipment, which is currently in use at the Naval Gun Factory—all of which will make NOL scientists and engineers able to simulate nearly any condition ordnance may be exposed to anywhere in the world.

Nearly everything has been done to make White Oak one of the best scientific research and development centers in the world.

Dedication of NOL X-ray Laboratory Marked by Symposium on Nondestructive Testing

DURING the last war, practically all military matériel agencies made extensive use of nondestructive testing in their own research, manufacturing, maintenance, and inspection plants. In addition, military agency quality control specifications required the setting up in industrial plants of approximately one thousand privately operated laboratories. In the case of the Navy Bureau of Ordnance, radiographic and associated methods proved to be so valuable that it was decided to establish the Nondestructive Testing Laboratory at White Oak, Md.

The dedication and symposium program on March 24 and 25 was designed to stress technical progress in the form of new methods, new equipment, and novel applications; but also, it was designed to contribute to two national defense administration problems. These problems are:

1. The interchange of nondestructive testing information between military and industrial agencies to minimize duplication of effort.
2. The preparation for industrial mobilization by initiating radical improvements in the procedures and quality standards which will be required of industries engaged in military manufacturing.

At the March 24 session six papers were presented by men engaged in providing new developments in the equipment and techniques for nondestructive tests. These papers were followed by a session on the morning of March 25 at which the application of nondestructive testing by the steel casting industry, the aluminum industry, the welding industry, and the magnesium industry was discussed. In the afternoon session, papers from Watertown Arsenal, Bureau of Ships, Bureau of Aeronautics, U. S. Air Force Matériel Command, and the Naval Ordnance Laboratory presented the current military applications of nondestructive testing.

The dedication ceremonies were attended by approximately 350 scientists and representatives of industry. A brochure containing the technical addresses will be prepared shortly by the Navy and copies made available to those interested.

White Oak is an outstanding example of a military-civilian team at work. The administrative side of the laboratory consists of a small group of naval officers with seagoing experience, under the command of Admiral Beatty. A graduate of Annapolis, with a mechanical engineering degree from M.I.T. he won his blue-and-white Navy cross as the skipper of the cruiser "Columbia" during the chips-down fighting in the South Pacific. The civilian research and development work is directed by Ralph Bennett, an expert on mine warfare. At present two members of A.S.T.M. Committee E-7 on Nondestructive Testing are members of the civilian staff of the Naval Ordnance Laboratory—Leslie W. Ball and D. T. O'Connor, the secretary of Committee E-7.

One of the most interesting installations at White Oak is the X-ray laboratory. The newest instrument to be installed is the world's first mobile betatron, a 10-million-volt X-ray generator whose rays are capable of penetrating 16 in. of steel. This betatron was demonstrated to the people attending the dedication ceremonies.

The massive betatron, first industrial machine whose rays will penetrate steel thicker than 12 in., is unique in that it may be aimed in any direction, whereas all other betatron, cyclotrons, and similar nuclear research equipment of this type are held in a fixed position. It will be used at White Oak principally for studying the complex internal assemblies of mines, torpedoes, and other items of Naval ordnance.

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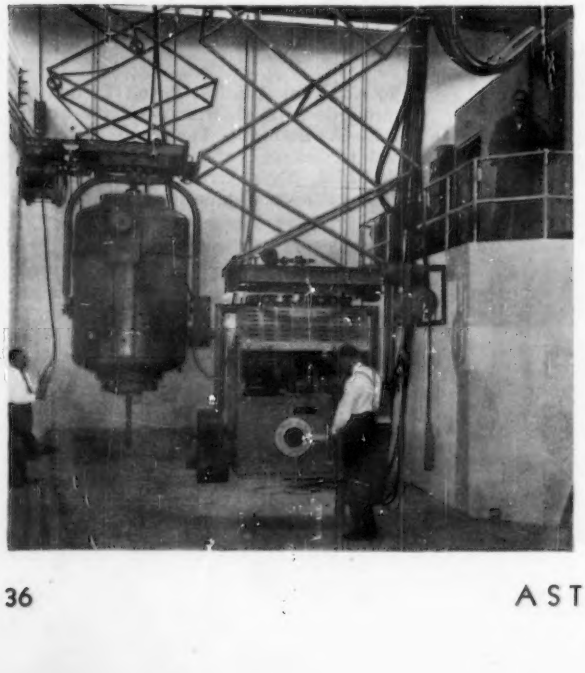


A portion of the Naval Ordnance Laboratory's X-ray Laboratory. In center is the Laboratory's newly installed 10,000,000-volt Betatron, and X-ray generator manufactured to Navy Specifications as an aid in nondestructive testing work. It is the world's first mobile high-voltage X-ray machine.

Dr. Kienle to Give Mattiello Lecture

ANNOUNCEMENT has been received from the Federation of Paint and Varnish Production Clubs that Dr. Roy H. Kienle, Director of Application Research, American Cyanamid Co., Calco Chemical Division, will deliver the first Joseph J. Mattiello Memorial Lecture.

Dr. Kienle is a graduate of Worcester Polytechnic Institute and Union College, and received his Ph.D. degree from Rutgers University. He is the author of many scientific papers published in the fields of polymers, coating compositions, dyes, textile dyeing, spectrophotometry, and pigments. He is a member of many scientific organizations, and is widely known for his patents in the fields of polymers, alkyd resins for coating compositions, dyes, and pigments.

The lecture will cover some phase of chemical research, either in or related to the protective and decorative coatings industry, the title to be announced at a later date.

The late Joseph J. Mattiello was very active in the work of A.S.T.M., particularly in Committee D-1 on Paint, Varnish, Lacquer, and Related Products, and in 1946 delivered a memorable Edgar Marburg Lecture on the subject "Protective Organic Coatings as Engineering Materials."

Vannevar Bush Receives Research Institute Medal

DR. VANNEVAR BUSH, who as chairman of the Office of Scientific Research and Development was "chief of staff" for American science during World War II, recently received the 1949 medal of the Industrial Research Institute.

The award was presented by H. W. Graham, Vice-President, Jones and Laughlin Steel Co. and Senior Past President of the Institute. E. W. Engstrom, Institute President and Vice-President in Charge of Research, RCA Laboratories, presided.

Dr. Bush also received a scroll bearing this citation: "Dr. Vannevar Bush for his leadership in the Office of Scientific Research and Development, in marshalling industrial and academic research and coordinating it with the military effort in the common defense, developing an instrument of government so effective as to provide a pattern for continued service."

Dr. Bush, who has been President of the Carnegie Institution in Washington since 1939, became chairman of the National Defense Research Committee in 1940 and headed the OSRD the following year. He resigned from the government organization last year in order to devote more time to the presidency of the Carnegie Institution. From 1919 to 1939 Dr. Bush was associated with the Massachusetts Institute of Technology, first as a professor and later as Vice-President and Dean of Engineering.

The I.R.I.'s medal is given for outstanding accomplishment in the management field of industrial research. The Institute seeks to promote, through its members, more economical and effective techniques of organization, administration, and operation of industrial research. It was organized in 1938 under the auspices of the National Research Council and now has a membership of 110 companies, with research staffs numbering more than 25,000 persons.

Proceedings of the 33d Annual Convention of the A.A.S.H.O.

THE 1947 Proceedings (Convention group meetings) of the American Association of State Highway Officials, covering committee activities in connection with the New York City meeting in September, 1947, has now been distributed.

The book contains a wealth of valuable information on all phases of highway engineering and administration based on the experience of many highway engineers and officials. The subject matter is grouped into sections representing the spheres of the several committees of the Association. These cover Administrative Practices, Highway Finance, Legal Affairs, Bridges and Structures, Construction, Maintenance and Equipment, and Roadside Development. In addition the panel discussions on Highway Department Public Relations and Urban Problems are included.

A limited edition has been printed and the price is $3 per copy

Modern Metallurgy for Engineers

REPLETE with many illustrations, tables, diagrams, and references, this second edition of Frank T. Sisco's book is an excellent one for those who are concerned with the relation of metals and their alloys to the structures and machines designed and constructed under the supervision of engineers. Written in metallurgical language which can be easily understood, it is an excellent textbook for a metallurgy course given to students in other branches of engineering. Because the book is written primarily for engineers most of the space is devoted to the art of metallurgy and there is little on the science.

The author has emphasized the hardenability of steel isothermal transformations, and other closely allied phenomena encountered in thermal treatment. He feels that the data recently obtained in this field have given a far clearer picture than before of the structural changes in carbon and low-alloy steels caused by heat treatment, and of the relation of structure to engineering properties.

The book of 450 text pages has been broken down into chapters covering the following subjects:

1. Metallurgy and Engineering
2. The Fundamental Structure of Metals and Alloys
3. The Manufacture of Iron and Steel
4. The Composition of Carbon and Alloy Steels
5. The Constitution of Steel
6. Fundamentals of the Heat Treatment of Steel
7. The Operations of Heat Treatment
8. The Significance of the Static Properties of Metallic Materials
9. The Significance of the Dynamic Properties of Metallic Materials
10. Machinability Wear Resistance, and Deep-Drawing Properties
11. Carbon Steel as an Engineering Material
12. Gray Cast Iron and Malleable Cast Iron
13. Low-Alloy Steels as Engineering Materials
14. Fundamentals of Hardenability
15. The Hardenability of Carbon and Low-Alloy Steels
16. High-Alloy Steels as Engineering Materials
17. Tool Steels, Die Steels, and Cemented Hard Carbides
18. Precipitation Hardening and Constitution of Non-Ferrous Alloys
19. Light Alloys as Engineering Materials
20. Copper and Copper-Base Alloys as Engineering Materials
21. Miscellaneous Heavy Non-Ferrous Alloys
22. Corrosion and Corrosion Resistance
23. The Effect of Temperature on the Mechanical Properties of Ferrous and Non-Ferrous Alloys

As to the authenticity of the material covered, not much needs to be said. It is sufficient to note from the preface that Mr. Sisco has been fortunate to have outstanding authorities in the various fields of metallurgy covered review his manuscript. Mr. Sisco himself is now Metallurgist and Editorial Director, Alloys of Iron Research, the Engineering Foundation. He was formerly Chief of Metallurgical Laboratory, U. S. Army Air Corps, Wright Field.

Copies of this 520-page publication can be obtained from the Pitman Publishing Corp., 2 West 45th St., New York, N. Y., at $5 per copy.

Soil Mechanics Proceedings Available

EIGHT noteworthy volumes of collected papers on soil mechanics and foundation engineering are now available for immediate or early delivery. All have been prepared in conjunction with the Second International Conference on Soil Mechanics and Foundation Engineering held at The Hague, Netherlands, last June.

The Proceedings of the Conference consist of six quarto volumes of about 330 pages each. The first five of these volumes contain 361 papers covering every phase of soil mechanics and foundation engineering written by authors from nearly all parts of the world. Particular emphasis has been placed on field observations, field testing and foundation, dam, highway, and airfield construction.

The sixth volume, scheduled for release before January 1, 1949, will contain the lectures, reviews, and discussions presented at the Conference meetings.

Because of the unprecedented number of valuable papers submitted to the Conference, a seventh volume of Proceedings is scheduled to be published if sufficient orders are received. It will contain forty-one papers from all parts of the world plus twenty-three papers prepared as a group by French engineers

and published originally in *Travaux*, June, 1948. Although these sixty-four papers were submitted too late to be printed in the first six volumes, they include a number of the most significant contributions to the Conference.

Orders for Conference Proceedings should be sent to the Secretary, Second International Conference on Soil Mechanics and Foundation Engineering, Oostplantsoen 25, Delft, The Netherlands. The costs of the Proceedings are: Vols. I to VI—75 guilders (approximately $28.30); Vol. VII—15 guilders (approximately $5.65). Remittances should be sent with orders in the form of bank drafts payable to the Treasurer of the Conference, c/o Amsterdamsche Bank, Delft, The Netherlands. Orders for Vol. VII should be placed as promptly as possible, because the number printed will depend on orders received.

Because of currency, travel, and other restrictions, German engineers did not participate in the Conference. They have, however, collected into one volume the German developments in soil mechanics and foundation engineering since 1939. This volume is entitled "*Abhandlungen ueber Bodenmechanik und Grundbau, 1939–1948.*" It is a quarto volume of 215 pages beginning with a review of German soil mechanics activities since 1939, followed by thirty-one individual papers and concluding with a classified bibliography listing 234 German publications of the period 1939–1948. Professor Terzaghi says of this volume: "It contains a competent survey of what has been done in Germany in the field of soil mechanics since 1939 including records of field observations and investigations which deserve our attention. The records cover large-scale loading tests, application of geophysical methods to subsoil exploration, and experiences with peat displacement by blasting. The German volume constitutes a useful supplement to the Proceedings of the Second Conference and fills a gap in the series of reviews of national soil mechanics activities which the Proceedings contain."

Arrangements are being made to sell the German book through the library of the Graduate School of Engineering, Harvard University, Cambridge, Mass., at a cost of $6.50. Funds realized from the sale of this volume will be used to purchase Proceedings of the Second International Conference and American soil mechanics publications for German libraries.

American engineers, engineering organizations, and libraries desiring to obtain copies of these volumes are urged to place orders as soon as possible whiie an adequate supply is still available.

Analytical Methods for Aluminum Alloys

THE 1948 edition of the Aluminum Research Institute "Analytical Methods for Aluminum Alloys" provides a newly revised collection of standard industry methods for the sampling and analy is of aluminum. As the approach of a group such as the Aluminum Research Institute to the problem of analysis of aluminum would be expected to differ somewhat from that of the A.S.T.M., so these methods will be found to bear certain similarities to A.S.T.M. Methods but to differ from them in other ways, although some of the same men have participated in the preparation of both groups of methods. This 104-page publication will accordingly be found of interest by many A.S.T.M. members, and is available from the Aluminum Research Institute, 111 W. Washington St., Chicago 2, Ill., at $1 a copy postpaid in the U. S., or $1.25 a copy outside of the U. S.

"Standards World" Bows

A NEW quarterly journal *Standard World* has appeared. This interesting publication is being issued under the editorship of S. P. Kaidanovsky, Washington, D. C. Mr. Kaidanovsky is concerned with many problems of standards and specifications in his business connections with the Federal Government, and is in close touch with many other standardization activities including A.S.T.M.

The first issue, comprising 124 pages (page size 6 by 9 in.), has a series of articles on such topics as "Standards and Measurement," "Standards Terms Defined," "Australian Standards," "Canadian Standards Agency," and standardization problems in such fields as welding, traffic engineering, milk industry, leather fields, and others. There is a series of book reviews and brief biographical sketches of prominent men in the field of standards, including A.S.T.M. President Richard L. Timplin.

The Editorial offices are located in Washington, and further information can be procured by writing to the Editors at Box 7593, Benjamin Franklin Station, Washington 4, D. C. The annual subscription to the magazine is $7.50.

The inside back cover of this first issue gives a pertinent quotation from one of the addresses of the first A.S.T.M. President, Dr. Charles B. Dudley. Wherever standardization work is under way the principle's enunciated by this outstanding man might well be kept in mind.

"A complete workable specification for material represents a very high order of work. It should combine within itself the harmonized antagonistic interests of both the producer and the consumer; it should have the fewest possible requirements consistent with securing satisfactory material; it should be so comprehensive as to leave no chance for ambiguity or doubt; and above all, it should embody within itself the results of the latest and best studies of the properties of the material which it covers."

Society Appointments

Announcement is made of the following appointments.

S. A. GORDON, The Glenn L. Martin Co. succeeding J. M. Frankland, Chance Vought Aircraft Division of United Aircraft Corp., and WALTER RAMBERG, National Bureau of Standards, succeeding D. E. Parsons, National Bureau of Standards, on the Administrative Committee on Simulated Service Testing.

A. G. ASHCROFT, Alexander Smith and Sons Carpet Co., reappointed as A.S.T.M. representative on ASA Committee on Ultimate Consumer Goods.

R. J. HARRINGTON, The Texas Company, replacing L. C. Beard, Socony-Vacuum Oil Co.; and R. H. TITLEY, Public Service Electric and Gas Co., replacing J. H. Ingmanson, the Whitney-Blake Co., as Society representatives on ASA Sectional Committee C59 on Electrical Insulating Materials.

N. L. MOCHEL, Westinghouse Electric Corp., C. L. KENT, Jones and Laughlin Steel Corp., and S. H. KILMER, Spang-Chalfant Division of National Supply Co., as Society representatives on ASA Sectional Committee B31 on Code for Pressure Piping, succeeding James Aston, A. M. Byers Co., and H. R. Redington, National Tube Co.

R. E. HESS, Assistant Executive Secretary, A.S.T.M., as alternate on ASA Electrical Standards Committee.

H. H. STOUT, JR., Franklin Institute, succeeding J. R. Becker, Westinghouse Electric Corp., deceased, as Society representative on ASA Sectional Committee C8 on Specifications for Insulated Wires and Cables.

O. G. STRIETER, National Bureau of Standards, representing Committee D-8, and RALPH O. CLARK, Gulf Research and Development Co., representing Committee D-2, on the Joint Committee on Chemical Analysis by X-Ray Diffraction Methods.

W. C. Voss, Massachusetts Institute of Technology, as representative of A.S.T.M. at Mid-Century Convocation on the Social Implications of Scientific Progress and the Inauguration of the tenth President of Massachusetts Institute of Technology.

J. W. WHITTEMORE, Virginia Polytechnic Institute, as representative of A.S.T.M. at the inauguration of Dr. Walter S. Newman as President of Virginia Polytechnic Institute.

Porter R. Wray, Carnegie-Illinois Steel Corp., on the Joint Committee on Definitions of Terms Relating to Heat Treatment, succeeding L. R. Fry, deceased.

S. A. Standing, Tung-Sol Lamp Works, on the Sectional Committee on Electron Tubes (C60), with T. H. Briggs, Superior Tube Co., as alternate.

New Members to April 22, 1949

The following 141 members were elected from February 27, 1949, to April 22, 1949, making the total membership 6557.

Names are arranged alphabetically—company members first, then individuals.

Chicago District

BAUER & BLACK, DIVISION OF THE KENDALL CO., P. F. Ziegler, Director of Research, 2500 S. Dearborn St., Chicago 16, Ill.

MINNESOTA PAINTS, INC., P. S. Eddy, Chief Chemist, 1101 S. Third St., Minneapolis 15, Minn.

ANDERSEN, KENNETH, Executive Vice-President, Scientific Apparatus Makers Assn., 20 N. Wacker Dr., Room 3120, Chicago 6, Ill.

BELL, EARLE H., Assistant, University of Illinois, Urbana, Ill. For mail: 406 E. Chalmers, Champaign, Ill. [J]*

BROKAW, B. A., Director, Petroleum Div., Minnesota Department of Taxation, 223 State Office Bldg., St. Paul 1, Minn.

CRANDALL, MORRIS, Director, Illinois Farm Supply Co., Kingston Mines, Ill.

DEXHEIMER, E. C., Manager, Technical Div., National Enameling and Stamping Co., Box 2043, Milwaukee 1, Wis. For mail: Box 6, Granite City, Ill.

EDELMANN, ROBERT, President, E. Edelmann and Co., 2332 Logan Blvd., Chicago 47, Ill.

FULKERSON, PAUL G., Chief Chemist, Three Rivers Filtration Plant, City Utilities, 308 E. Berry St., Fort Wayne 2, Ind.

KESLER, CLYDE E., Instructor, Theoretical and Applied Mechanics Dept., University of Illinois, 316 Talbot Lab., Urbana, Ill. [J]

KNAPP, H. C., Fairbanks, Morse and Co., Beloit, Wis.

KOEHRING, PHILIP ALFRED, Training Course, Koehring Co., 3026 Concordia Ave., Milwaukee 10, Wis. For mail: 5277 N. Berkeley Blvd., Milwaukee 11, Wis. [J]

KURZWEIL, CHRIS, Plant Manager, Chicago Show Printing Co., 2635 N. Kildare Ave., Chicago 39, Ill.

LINDEMANN, E. H., Chief Chemist, Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave., Minneapolis 8, Minn.

MITCHELL, RICHARD B., Textile Chemist, American Institute of Laundering, Box 1187, Joliet, Ill.

PRYATEL, FRANK J., Metallurgical Engineer, The Oliver Corp., Plant #1, 533 Chapin, South Bend, Ind.

SINCLAIR, GEORGE M., Research Assistant, University of Illinois, Room 321a Talbot Lab., Urbana, Ill.

WILLMORE, TRACY A., Ceramist, 1118 W. Illinois St., Urbana, Ill.

Cleveland District

HAUSERMAN CO., THE E. F., C. J. Nocar, Chief, Development Engineering, 6800 Grant Ave., Cleveland 5, Ohio.

CANFIELD, W. E., Vice-President—Sales, The S. K. Wellman Co., 1374 E. Fifty-first St., Cleveland 3, Ohio.

EVANS, ROBERT E., Chemical Engineer, Owens-Corning Fiberglas Corp., Case Ave., Newark, Ohio. For mail: 110 Fulton Ave., Newark, Ohio. [J]

LOWEY, FRANCIS J., Assistant Chief Engineer, The S. K. Wellman Co., 1374 E. Fifty-first St., Cleveland 3, Ohio.

SCHWARTZ, WILLIAM H., Chief Engineer, Lester Engineering Co., 2711 Church Ave., Cleveland 13, Ohio.

SCOTT, WALTER S., Metallurgical Engineer Republic Steel Corp., Republic Bldg., Cleveland 15, Ohio.

WHITE, FRANK FRETTER, Vice-President—Plant Operations, The S. K. Wellman Co., 1374 E. Fifty-first St., Cleveland 3, Ohio.

Detroit District

AJAX STEEL AND FORGE CO., J. H. Richardson, Engineer, 205 Adair St., Detroit 7, Mich.

ALMEN, J. O., Executive Consultant, Research Lab. Div., General Motors Corp., Detroit 2, Mich.

BABER, A. V., Manager, Insulation Sales, American Structural Products Co., Ohio Bldg., Toledo, Ohio.

DUTTWEILER, A. F., Chemist, Universal Die Casting and Manufacturing Corp., 232 Monroe St., Saline, Mich. [J]

HENDRICKS, HARVEY T., Supervisor, Mechanical Lab., Research Engineering, Ford Motor Co., Dearborn, Mich. For mail: 15755 St. Marys, Detroit 27, Mich.

HURON CLINTON METROPOLITAN AUTHORITY, George W. McCordic, Engineer-Director, 1100 Cadillac Square Bldg., Detroit 26, Mich.

KERLEY, R. V., Associate Director of Research, Ethyl Corp., 1600 W. Eight Mile Rd., Ferndale 20, Detroit, Mich.

KRESGE HOOKER SCIENTIFIC LIBRARY, WAYNE UNIVERSITY, 4841 Cass Ave., Detroit 1, Mich.

MICHIGAN STATE COLLEGE, MECHANICAL ENGINEERING DEPT., P. J. DeKoning, Assistant Professor of Mechanical Engineering, East Lansing, Mich.

SCHWARTZWALDER, KARL, Chief Ceramic Engineer, AC Spark Plug Div., General Motors Corp., 1300 N. Dort Highway, Flint, Mich. For mail: 2150 Rattalee Lake Rd., Holly, Mich.

SMITH, AUSTEN J., Associate Professor, Michigan State College, Department of Chemical and Metallurgical Engineering, East Lansing, Mich.

WILLIAMS, JACK L., Laboratory Director, The Dow Chemical Co., Midland, Mich. For mail: 602 George, Midland, Mich.

WINKWORTH, JOHN W., Transit Mix Div., Winkworth Fuel and Supply Co., 8829 W. Jefferson Ave., Detroit 17, Mich.

New England District

AMES PRECISION MACHINE WORKS, Robert W. Daly, Assistant to President, 131 Lexington St., Waltham 54, Mass.

CHRISTISON, LESLIE, Chemist, American Woolen Co., 1 Mill St., Lawrence, Mass.

DONOVAN, DANIEL J., Director of Public Works, City of Bristol, City Hall, Bristol, Conn. For mail: 134 Woodland St., Bristol, Conn.

DOW, ELWYN E., Quality Control Engineer, Saco-Lowell Shops, Biddeford, Me.

GIBSON, FRED W., Laboratory Technician, A. G. Spalding and Brothers, Inc., Chicopee, Mass.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, ACOUSTICS LABORATORY, Richard H. Bolt, Director, 77 Massachusetts Ave., Cambridge 39, Mass.

MUCHOW, A. J., Engineer, Engineering Lab., Telechron, Inc., Ashland, Mass.

STURGEON, STOCKER S., Chief Test Engineer, The Foxboro Co., 38 Neponset Ave., Foxboro, Mass.

New York District

LANCASTER PROCESSES, INC., Francis L. Mark, Sales Director, 620 Fifth Ave., New York 20, N. Y.

MALLEABLE IRON FITTINGS CO., Donald F. Sawtelle, Metallurgist, Branford, Conn.

BLOCH, PETER K., Vice-President, Branson Instruments, Inc., 436 Fairfield Ave., Stamford, Conn.

BURNS, ROBERT, Member of Technical Staff Bell Telephone Laboratories, Inc., Murray Hill Lab., Murray Hill, N. J.

CARTER, RICHARD H., Standards Engineer General Electric Co., Schenectady, N. Y.

GALE, CHARLES B., Assistant to President, Pan American Refining Corp., Pan American Petroleum and Transport Co., 122 E. Forty-second St., New York 17, N. Y.

GEBELEIN, C. F. W., Research Chemist, Esso Standard Oil Co., Chemical Products Lab., Box 222, Linden, N. J.

GUNZENHAUSER, A., Industrial Consultant, 136 Liberty St., New York 6, N. Y.

HARLOW, H. GILBERT, Associate Professor of Civil Engineering, Civil Engineering Dept., Union College, Schenectady, N. Y.

JAHN, ALFRED P., Member of Technical Staff, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

KEITH, JAMES R., General Manager, Research and Development Div., California Texas Oil Co., Ltd., 551 Fifth Ave., New York 17, N. Y.

LARSON, ANDERS P., President and Treasurer, The A. P. Larson Co., Inc., 29 Broadway, New York 6, N. Y.

LINDSAY, NORMAN W., Superintendent, Operations Dept., Westchester Lighting Co., 9 S. First Ave., Mt. Vernon, N. Y.

MAYERS, KARL F., Factory Engineer, National Union Radio Corp., 350 Scotland Rd., Orange, N. J. For mail: 302 Grove St., Somerville, N. J.

MINNER, J. L., Manager, Fuel Oil Dept., Shell Oil Co., Inc., 50 W. Fiftieth St., New York 20, N. Y.

PACKARD, H. C., Secretary, Loss Control Committee, Shell Oil Co., Inc., 50 W. Fiftieth St., New York 20, N. Y.

PAYNE, WILLIAM ARTHUR, Consultant, 4 Manchester Rd., Tuckahoe, N. Y.

POWSNER, MICHAEL, Materials Engineer, United States Testing Co., Inc., 1415 Park Ave., Hoboken, N. J. For mail: 8821 Seventeenth Ave., Brooklyn 14, N. Y.

RIDER, HERMAN C., Assistant Engineer, Material Inspection, New York Central System, New York, N. Y. For mail: 541 E. 152nd St., Cleveland 10, Ohio.

SANDS, JOHN W., Metallurgist, The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

SCHOTTLAND, FREDERIC D., Consulting Engineer, 104-18 Metropolitan Ave., Forest Hills, N. Y.

SPIESS, IRWIN, 850 E. 181st St., New York 60, N. Y. [J]

WEISMANTLE, ARTHUR R., Assistant Manager, Steam Div., Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.

WILBER, DAVID T., Research Chemist, Allen B. DuMont Labs., Inc., Box 1079, Passaic, N. J.

WILHELMY, FRED, The Ansonia O & C Co., Ansonia, Conn.

WILLIAMS, FRANCIS J., Technical Director, National Lead Co., 105 York St., Brooklyn 1, N. Y.

Northern California District

BERKELEY, CITY OF, PURCHASING AND BUDGET DEPT., W. Hunrick, Jr., Purchasing Agent and Budget Officer, Room 212, City Hall, Berkeley 4, Calif.

MCLENNAN, LESTER W., Supervisor, Union Oil Company of California, Oleum, Calif. For mail: 2619 Yuba Ave., Richmond, Calif.

RAITT, GEORGE H., Consulting Engineer, 44 El Camino Real, Berkeley 5, Calif.

UNIVERSITY OF CALIFORNIA LIBRARY, Blanche H. Dalton, Librarian, Engineering Branch, Berkeley 4, Calif.

VON BOHLAR, EDGAR, Chief Engineer, Yuba Manufacturing Co., 351 California St., San Francisco 4, Calif.

Ohio Valley District

(In Course of Organization)

HEDGES, W. D., Chemical Superintendent, Columbus Coated Fabrics Corp., Seventh and Grant Aves., Columbus 16, Ohio.

HOLTMAN, C. W., Chief Engineer, Metallurgical Dept., American Radiator and Standard Sanitary Corp., 1541 S. Seventh St., Louisville 8, Ky.

PURDY, ROBERT J., Technical Director, Orr Felt and Blanket Co., Piqua, Ohio.

Philadelphia District

BACON, W. GARWOOD, JR., Sales Manager, Rug and Electrical Div., E. W. Twitchell, Inc., Third and Somerset Sts., Philadelphia 33, Pa.

BRYAN, GEORGE S., Acting Dean, Schools of Technology, International Correspondence Schools, Scranton 9, Pa.

EDSON, MURRAY H., Technical Editor, Lefax, Inc., Philadelphia, Pa. For mail: 24A Garden Dr., Roselle, N. J.

HORNER, J. R., Regional Engineer, Structural Clay Products Inst., Mid-Atlantic Region, 1518 Walnut St., Rm. 807, Philadelphia 2, Pa.

LeCron, John R., Assistant Metallurgical Engineer, Bethlehem Steel Co., Inc., Rm. 507, Bethlehem, Pa.

Mikita, J. J., Petroleum Laboratory Director, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del. For mail: 818 Greenwood Rd., Wilmington, Del.

Sener, Donald, Metallurgist, Harrisburg Steel Corp., Harrisburg, Pa. For mail: 1626 Market St., Harrisburg, Pa.

Shaputnic, John P., Assistant Plant Chemist, Giant Portland Cement Co., Egypt, Lehigh County, Pa. For mail: 702 Union St., Allentown, Pa.

Snyder, Edward B., Technical Director, Kimble Glass Division of Owens-Illinois Glass Co., Conshohocken, Pa.

Tinney, Thomas B., Chief Chemist, Philadelphia Gas Works Co., Thirty-first St., and Passyunk Ave., Philadelphia 45, Pa.

Tomlinson, Ernest G., Designer, Damon & Foster, Sharon Hill, Pa. For mail: 4823 N. Hope St., Philadelphia 20, Pa. [J]

Watson, Harold F., Assistant Chief Engineer, Link-Belt Co., General Engineering Div., 1955 W. Hunting Park Ave., Philadelphia 40, Pa. For mail: 519 E. Tulpehocken St., Philadelphia 44, Pa.

Pittsburgh District

Bowman, John J., Metallurgist, Aluminum Company of America, 801 Gulf Bldg., Pittsburgh 19, Pa.

Dillon, G. Milton, Superintendent, Public Works, Borough of Braddock, Municipal Bldg., Braddock, Pa. For mail: 27 Holland Ave., Braddock, Pa.

Enzian, George H., Research Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa. For mail: 40 Longworth St., Pittsburgh 7, Pa.

Kurtz, B. F., Chief Engineer, Pressed Steel Car Co., Inc., 2500 Koppers Bldg., Pittsburgh 30, Pa.

Llewelyn, David S., Jr., Chief Inspector, Carnegie-Illinois Steel Corp., Duquesne, Pa. For mail: 122 Slater Dr., Pittsburgh 27, Pa.

Pinney, M. A., Engineer of Tests, The Pennsylvania Railroad Co., Altoona, Pa.

Rumisek, John G., Chemist, Globe Varnish Co., Inc., 612 La Schall St., Pittsburgh 8, Pa. For mail: 1305 Clark St., Pittsburgh 21, Pa.

Seastone, J. B., Manager, Materials Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Sperry, Harold C., Engineer, Aluminum Company of America, 801 Gulf Bldg., Pittsburgh 19, Pa. For mail: 333 Fourth St., Beaver, Pa.

St. Louis District

Bendy, W. R., Consulting Engineer, 9403 Riverview Dr., St. Louis 15, Mo.

Southeast Missouri State College, Kent Library, F. E. Snider, Librarian, Cape Girardeau, Mo.

Washington (D. C.) District

Aaron, Jacob C., Salesman, Fibre Board Container Co., Martinsville, Va. For mail: 1200 Ranson Rd., Martinsville, Va.

Bartel, Fred F., Assistant Director of Engineering, National Sand and Gravel Assn., 1325 E St., N. W., Washington 4, D. C.

Gordon, Samuel A., Chief Structural Test Engineer, Glenn L. Martin Co., Baltimore, Md. For mail: 5722 Narcissus Ave., Baltimore 15, Md.

Western New York-Ontario District

Cory, Myron T., Development and Research Manager, Great Lakes Carbon Corp., Box 637, Niagara Falls, N. Y.

Dowling, Arthur P., Chemist, Colonial Radio Corp., 1280 Main St., Buffalo, N. Y.

Kaiser, Henry L., Metallurgist, The Standard Stoker Co., Inc., 1701 Gaskell Ave., Erie, Pa.

Lapp, Grover W., Consulting Engineer, Lapp Insulator Co., Inc., ReLoy, N. Y.

Moore, H. M., Purchasing Agent, Purchasing and Stores Div., City of Toronto, Treasury Dept., Room 203, City Hall, Toronto 1, Ont., Canada.

Purcell, Walter J., Assistant Professor, Department of Engineering Materials, College of Engineering, Cornell University, Lincoln Hall, Ithaca, N. Y.

Robinson, W. H., Chief Chemist, Sternson Laboratories, Ltd., Box 459, Brantford, Ont., Canada.

Weiner, Albert, Engineer of Materials, U. S. Concrete and Soils Laboratory, Tower Rd., Ithaca, N. Y.

White, Mary Vivian, Instructor, New York State College of Home Economics, Cornell University, Ithaca, N. Y.

U. S. and Possessions

Dow Chemical Co., The, Texas Division Library, Plant A-1204, Freeport, Tex.

Cabaniss, Jack K., Consulting Engineer, 213 S. Third St., Albuquerque, N. Mex.

Carter, Eugene H., Partner, Carter & Burgess, 401 Century Bldg., Fort Worth 2, Tex.

Cronin, T. J., District Manager, Pittsburgh Testing Laboratory, 4137 Dennis St., Houston 4, Tex.

Doan, W. E., General Manager, Forest Products Treating Co., 541 Pittock Block, Portland 5, Ore.

Goldemberg, Jaime, Instructor in Civil Engineering, Seattle University, 900 Broadway, Seattle 22, Wash. [J]

Hoiberg, Arnold J., Director, Asphalt Technical Service and Development, Lion Oil Co., El Dorado, Ark.

Johnson, Frank B., Esso Labs., Esso Standard Oil Co., Louisiana Div., Box 551, Baton Rouge 1, La.

Locheed, E. W., American Republics Corp., Petroleum Bldg., Houston 2, Tex.

Milek, W. A., Jr., Omaha Steel Works, Engineering Dept., 609 S. Forty-eighth St., Omaha 6, Nebr.

Thoman, William H., Professor of Civil Engineering, Department of Civil Engineering, University of Colorado, Boulder, Colo.

Van Hovenberg, H. W., Engineer of Tests and Sanitation, St. Louis Southwestern Railway Co., Box 288, Mt. Pleasant, Tex.

Other than U. S. Possessions

Concrete Development Corp. (Pty) Ltd., Peter J. Doanides, Managing Director and Chief Engineer, Box 8792, Johannesburg, South Africa.

Sumerbank Cimento Sanayii Muesseses, Mitat Ersoz, Engineer, Sivas, Turkey.

Belgium, Ministere des Travaux Publics, Henri Van Huffel, Librarian, Rue de la Loi 155, Brussels, Belgium.

Byman, Ragner, Chief of Division, Kungl. Armeforvaltningen, Tygavdelningen, Box 14073, Stockholm 14, Sweden.

Claire, Jaswant Sinah, Works Manager, Government Central Workshops, Amritsar, East Punjab, India.

Hales, R. E., Anglo-Egyptian Oilfields, Ltd., Box 228, Cairo, Egypt.

Iyengar, B. R. N., Assistant Professor, University of Mysore, College of Engineering, Bangalore, India.

Magyar, Stephen, Research Engineer, Von Roll Iron Works, Ltd., Gerlafingen, Switzerland.

Matthysen, Henri Louis, Chief, Testing Dept., Netherlands Railways, Hoofdgebouw III, Room 6, Moreelsepark, Utrecht, Netherlands.

Milligan, James, Technical Director, M. Barr and Co., Ltd., 110 Dobbies Loan, Glasgow C.4, Scotland.

Rees Jones, Aneurin, Technical Manager, Parkinson Stove Co., Ltd., Stechford, Birmingham 9, England.

Roegiers, Michel, Member of Firm, Societe des Hufiles De Cavel & Roegiers, S. A., Coupure 221, Gand, Belgium.

Soete, Walter, Director, University of Gent, St. Pietersnieuwstraat 57, Gent, Belgium.

Valko, Andrew, Chief Engineer, Manfred Weiss, 62, P.O.B. 148, Budapest, Hungary.

*[J] denotes Junior Member.

PERSONALS • • •

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—*These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.*

J. J. Allen, Chief Chemist of the Firestone Tire and Rubber Co., has been transferred from the Fall River Rubber and Latex Products Division to the Firestone Industrial Products Co., Akron, Ohio. Mr. Allen has been active in A.S.T.M. work for many years, being representative of Firestone's Sustaining Membership since 1933, member of the Executive Committee 1939–1941, and a participant in the activities of Committee D-11 on Rubber. He has also served as a Councilor of the New England District Council.

The **American Petroleum Institute Division of Refining** at its recent meeting in Houston, Tex., presented Certificates of Appreciation to the following: T. G. Delbridge, formerly with the Atlantic Refining Co., Philadelphia, and a Past-President of A.S.T.M., and Honorary Member of Committee D-2 on Petroleum; K. G. Mackenzie of The Texas Company, New York City, also an A.S.T.M. Past-President and active for years in the Society, especially Committee D-2, serving as its Secretary 1914–1922; and Walter Samans, Sun Oil Co., Philadelphia, an active member of Committee A-1 on Steel.

Fred F. Bartel, has accepted an appointment in the Engineering Dept., Tews Lime and Cement Co., Milwaukee, Wis. He had been associated with the National Sand and Gravel Assn., Washington D. C., as Assistant Director of Engineering.

R. S. Bradley, for many years Director of Research, A. P. Green Fire Brick Co., Mexico, Mo., has been appointed head of his company's new Research & Engineering Division, created to tie together more closely Research, Plant Engineering, and Industrial Engineering, and to give added emphasis and development in the company's future course. Mr. Bradley is very active in the work of A.S.T.M., particularly in Committee C-8 on Refractories, of which he is Vice-Chairman.

Willis B. Clemmitt has been elected a Vice-President, Freyn Engineering Co., Chicago. He has been associated with the company since 1923, and has served a considerable number of years as Chief Engineer.

Donald L. Colwell, Sales Engineer of the Apex Smelting Co., Chicago, Ill., has returned from abroad. He and Albert Butler, of Denver, were sent to six European countries by the Economic Cooperation Administration to examine the aluminum requirements of Europe. Their recommendations should help to alleviate the tightness in aluminum supplies.

L. S. Crane has been promoted to Engineer of Tests, Southern Railway System, Alexandria, Va.

Thomas H. Daugherty has been named Assistant Director of Research for Calgon, Inc., Pittsburgh, Pa.

Peter J. Doanides, formerly Lieutenant and Civil Engineer, Royal Hellenic Navy, Greek Embassy, Washington, D. C., is now Managing Director and Chief Engineer, Concrete Development Corp. (Pty.) Ltd., Johannesburg, South Africa.

F. Kermit Donaldson, recently Vice-President and General Manager, The Machined Steel Casting Co., Alliance, Ohio, has been appointed Executive Vice-President of the Steel Founders' Society of America, Cleveland. He comes to his new position after an affiliation of 30 years with The Machined Steel Casting Co., where he was continuously identified with the growth and development of that company. He was elected President of the Steel Founders' Society for 1948, and has served as a Director of the Society for five years. He is also active in the work of the National Munitions Board. Mr. Donaldson's hobby is music; he plays the bassoon in the Canton, Ohio, Symphony Orchestra, and in the fall of 1949 the Mount Union College Symphony Orchestra will play one of his compositions.

Robert A. Emmett has been advanced to Assistant Technical Director in Charge of Rubber Service at Binney & Smith Co., New York City. He comes from the Akron office.

John R. Ferree, formerly Superintendent, Sherwin Williams Argentina, S. A., Buenos Aires, Argentina, is now Supt. of Production, The Sherwin-Williams Co., Los Angeles, Calif.

James B. Fisher, Vice-President and Chief Engineer, Waukesha Motor Co., Waukesha, Wis., has retired and is succeeded as Chief Engineer by **Lloyd L. Bower,** who has been assistant since 1940. Mr. Fisher continues as a director.

Herbert J. Gilkey, Head, Dept. of Theoretical and Applied Mechanics, Iowa State College, Ames, was elected President of the American Concrete Institute at its recent 45th Annual Convention in New York City. **Frank H. Jackson,** Principal Engineer of Tests, Public Roads Administration, Washington, D. C., was elected Vice-President. Both Professor Gilkey and Mr. Jackson are long-time members of A.S.T.M., being especially active in the work of Committees C-1 on Cement and C-9 on Concrete and Concrete Aggregates.

E. W. Gilliland, Chief Chemist, Mine Safety Appliances Co., Pittsburgh, Pa., is a candidate for Chairman-Elect of the Pittsburgh Section of the American Chemical Society.

Edwin A. Glenn, Jr., has joined the New Holland Machine Co., New Holland, Pa., as Metallurgist for the Development Engineering Department. He had been Senior Metallurgist in the Research Department of Mack Mfg. Corp., Plainfield, N. J., and previously was with the American Car & Foundry Co.

Julius B. Goldberg, Research Director, J. P. Stevens and Co., Inc., New York City, has been elected a Fellow of the British Textile Institute.

W. M. Holaday, Director of Research, Socony-Vacuum Oil Co., New York City, has been named Chairman of the recently formed Committee on Fuels and Lubricants, organized by the Research and Development Board to determine policies on research and development in the field of fuels and lubricants as they affect the National Military Establishment. The committee's responsibilities include consideration of organic and inorganic liquid, solid and gaseous fuels, lubricating oils and antifreeze compounds. The group will also study equipment and techniques for production, storage and handling, and dispensing; and will assume functions of the Research and Development Board Panel on Petroleum which has been working on problems in the field of petroleum since June, 1948. Membership of the committee comprises three civilian members and two representatives each from the Army, Navy, and Air Force.

Harry K. Ihrig, Vice-President and Director of Laboratories, Globe Steel Tubes Co., Milwaukee, Wis., recently received a citation for distinguished service in engineering from the College of Engineering of the University of Wisconsin.

C. W. Jameson, Founder and President of the Atlas Electric Devices Co., Chicago, Ill., has disposed of his interest in the company and has retired from active work, his home address being 342 W. Windsor Ave., Lombard, Ill. During his business career, he has seen the Weather-Ometer, the Launder-Ometer, and other "Ometers" come into use throughout the world. Mr. Jameson indicates that the founding and carrying on of this business was a wonderful experience, but now he is glad to retire and enjoy his home, garden, workshop, and association with his friends.

John W. Jones, formerly Chemist, Oak Ridge National Laboratory, Div. of Carbide and Carbon Chemicals Corp., Oak Ridge, Tenn., is now Senior Scientist, Oak Ridge Institute of Nuclear Studies, Oak Ridge.

C. E. Kaufman, formerly Research Engineer, has been appointed Assistant Director of Chemical Research, Hall Laboratories, Inc., Pittsburgh, Pa.

G. E. F. Lundell, retired Chief of the Chemistry Division at the National Bureau of Standards, was awarded the $1000 Fisher Award in Analytical Chemistry by the American Chemical Society at its recent West Coast meeting. A Past-President of A.S.T.M., Dr. Lundell is Honorary Chairman of Committee E-3 on Chemical Analysis of Metals.

G. C. MacDonald, formerly with Montgomery, Ward and Co., Chicago, Illinois, has been appointed Test Director, Research and Development Branch, Military Planning Division, Office of the Quartermaster General, Washington, D. C.

Paul D. Merica has been elected Executive Vice-President of the International Nickel Co., New York City. Dr. Merica is a long-time member of A.S.T.M. and served on the Executive Committee for two terms.

Lloyd M. Morris has been promoted to Assistant Engineer of Tests, The Pennsylvania Railroad, Altoona, Pa.

J. B. Neiman, widely known in the metal industries for many years, has announced his resignation as General Manager of the General Aluminum Dept. of Federated Metals Div., American Smelting and Refining Co., Detroit, Mich., effective as of June 1, 1949. Mr. Neiman has been with Federated Metals and its predecessors in various executive capacities since 1911. He has been President of the Aluminum Research Institute for the past eight years. During the last war he was very active in various Governmental agencies such as the War Production Board, the Metals Reserve Company of the R.F.C., etc. At the close of the war he acted as Co-Chairman of the Overseas Scrap Advisory Committee which the Army Headquarters sent overseas in 1945 to inspect the Army Surplus accumulations and advise on the orderly disposal thereof. Mr. Neiman's headquarters will continue to be at 729 Fisher Building, Detroit, Mich. Further details of his plans will be announced later.

H. Neville Potter has been elected Executive Vice-President and General Manager of Dearborn Chemical Co., Ltd., Toronto, Canada. He is Technical Director of the company and a member of the Board of Directors.

Robert H. Prislin, formerly Technical Director, Ferro Enamel Corp., Cleveland, Ohio, is now Manager, Industrial Finishes Dept., National Lead Co., Burlingame, Calif.

Frederick N. Rhines has been promoted to a full professorship at the Carnegie Institute of Technology, College of Engineering and Science, Department of Metallurgical Engineering. Dr. Rhines is the Aluminum Company of America Professor of Light Metals and a two-time winner of the Institute of Metals Award.

Frank E. Richart, Professor of Engineering Materials, University of Illinois, Urbana, is Chairman of the present Award Committee for the recently announced Award of the Concrete Reinforcing Steel Institute "in recognition of a noteworthy contribution to the advancement of reinforced concrete construction."

J. P. Sanders, formerly Materials Engineer, U. S. Coast Guard, Washington, D. C., is now Technologist, Specifications Section, National Bureau of Standards, Washington, D. C.

Richard C. Savage is now affiliated with the National Lead Co., South Pasadena, Calif., as Industrial Chemist. He was previously Chief Chemist, Old Colony Paint & Chemical Co., Los Angeles.

Charles H. Sawyer, Research Engineer of Eastern Gas and Fuel Associates, Coal Div., Sales Dept., Pittsburgh, Pa., has been appointed Chairman of the joint Bituminous Coal Research-Stoker Manufacturers' Assn. committee for the development of a standard test for evaluation of stoker coals, replacing L. L. Connell who recently resigned because of a change in his work. Mr. Sawyer has been a member of this committee since its establishment two years ago and is in general charge of his company's stoker research program. Eastern Gas and Fuel Associates, Stoker Research Laboratory will be one of four initially cooperating in the development of this test method. Identical test sets are also being installed at Battelle Memorial Institute, the Illinois Geological Survey, and the Ottawa Laboratories of the Canadian Bureau of Mines.

Hsin-Chong Shih, who recently completed an intensive engineering training course in United States foundries and foundry equipment plants, has been appointed Manager of Foreign Industrial Relations of the Hsin Hwa Engineering Co., Shanghai. A graduate of Shanghai's Ta-Tung University in 1946 with a B.S. in Electrical Engineering and Metallurgy, Mr. Shih became a student engineer in this country, successively with the Pittsburgh Lectromelt Corp., Lingberg Engineering Co., Wheelco Instrument Co., Western Foundry Co., and the Badger Malleable & Mfg. Co.

Frank T. Sisco, Director of Alloys of Iron Research, New York City, has been appointed Technical Director of the Engineering Foundation, a joint research agency of A.S.C.E., A.I.M.E., A.S.M.E., and A.I.E.E., sponsoring and supporting fundamental research in all fields of engineering. Mr. Sisco has been in charge of Alloys of Iron Research since 1930, and for the present will continue with this project in addition to his duties as director of the research activities of Engineering Foundation.

H. L. Smith, formerly Field Metallurgist with the Federated Metals Div., American Smelting & Refining Co., Pittsburgh, Pa., has been appointed to the newly created position of Executive Technical Engineer of the Division. Mr. Smith has been Field Metallurgist since 1939, working with customers on development and production problems. In his new position he will be aided by a staff of service engineers and foundry technicians, who will assist him in broadening the services of the company to the non-ferrous metal-working industry.

Foster Dee Snell, President of Foster D. Snell, Inc., has been named to receive the 1949 Gold Medal of the Society of Chemical Industry, London, awarded biannually by the Society to a person "who has attained eminence in applied chemistry." Dr. Snell will be awarded the medal at the Society's meeting at Manchester, England, in July, when he will deliver an address on a phase of surface activity. His special field of personal interest is surface-active phenomena, which embraces the action of soaps, detergents, wetting agents, and similar products.

Marshall H. Switzer, formerly associated with C. Olin Ball, Consulting Food Technologist and Associates, Maumee, Ohio, is now with the Continental Can Co., Inc., Research Dept., Chicago, Ill.

John F. Thompson has been elected President of International Nickel Co. of Canada Ltd., Copper Cliff, Ont., Canada.

Werner von Bergen, Director of Research, Forstmann Woolen Co., Passaic, N. J., has been made a Fellow of the Textile Institute (England).

John W. Whittemore, Professor of Ceramic Engineering, Virginia Polytechnic Institute, Blacksburg, served as A.S.T.M. delegate to the inauguration of Walter Stephenson Newman as President of the Institute on April 18, 1949.

Ralph L. Wilcox, Vice-President in Charge of Industrial Sales and Engineering, Gerity-Michigan Corp., Adrian, Mich., has been transferred to Washington on special assignment for his company.

After 30 years of service as a civilian with the United States Navy, **Karl D. Williams**—known to his large number of A.S.T.M. friends and the staff as "K.D."—has retired. The Navy personnel have been concerned particularly with work on steel and other ferrous metals and many in the non-ferrous field, but because of the wide range of materials used in the construction and maintenance of our fleet, the Bureau of Ships has also been concerned with A.S.T.M. activities involving fuel oil, lubricants and other petroleum products, water and many others. Various Bureau of Ships personnel have followed this work and different naval officers have acted as the official representative of the Bureau membership, but for many years the man who has occupied a most important place in correlating and integrating the interests of the Bureau of Ships in the Society has been Mr. Williams. It is not possible to list all the contributions that he has made to A.S.T.M. work but these have ranged beyond the purely technical aspects of the Navy's problems. He has sat in the councils of the Steel Committee's advisory group, has been interested in the Washington District Council, and other A.S.T.M. affairs. In his retirement all of his Society friends and the several staff members who have known him for years extend him best wishes, and these notes may serve as an expression of appreciation and of the high esteem in which he is held.

NECROLOGY

Fred G. Allison, Materials Engineer, U. S. Engineer Dept., most recently stationed at Camp Edusa, Guam; previously with the Engineer Dept. in Havana and Honolulu, also with the U. S. Maritime Commission, Regional Construction Office in New Orleans in 1943, and formerly with the Pennsylvania Turnpike Commission and State Highway Board of Georgia. Member since 1937.

A. J. Boase, Portland Cement Assn., Chicago, Ill. (February 9, 1949). Representative of Portland Cement Assn. on Committee E-6 on Methods of Testing Building Constructions where he rendered service on several subcommittees.

Walter J. Brown, National Lead Co., Brooklyn, N. Y. (March 13, 1949). Mr. Brown represented his company on Committee E-3 on Chemical Analysis of Metals, his service on that group dating from 1935. He also participated in the activities of Committee B-2 on Non-Ferrous Metals and Alloys for more than ten years.

Lewis R. Ferguson, Vice-President, Lone Star Cement Co., Dallas, Tex. (February 23,1949). Affiliated with A.S.T.M. since 1909, Mr. Ferguson was one of the group of this year's Forty-Year Members. He had rendered active service on several committees, particularly C-1 on Cement, of which he was made an Honorary Member in 1948.

Arthur R. Howe, Vice-President and Director of Ludlow Manufacturing and Sales Co., Ludlow, Mass. (February 23, 1949). A representative of his company since 1936 on Committee D-13 on Textiles, Mr. Howe was the organizer of the Subcommittee on Bast and Leaf Fibers of that group, serving as its Chairman 1936–1940. He was particularly interested in the development of standard methods in the jute and cordage industry. An authority in his field, Mr. Howe was a member of the 1919 class at Harvard, and during World War II served as Chief of the Cordage Branch of the War Production Board. He was also a member of the Advisory Committee of the National Munitions Board and a town official in Sudbury, Mass.

Charles S. Hyatt, Vice-President, Columbus Coated Fabrics Corp., Columbus, Ohio (March 8, 1949). Member since 1947, and member of Committee D-1 on Paint, Varnish, Lacquer, and Related Products, serving on several subcommittees.

Harvey G. Kittredge, President, The Kay & Ess Co., Dayton, Ohio (November 6, 1948). Member of the Society since 1903, and an active participant for many years in the activities of Committee D-1 on Paint.

Frank H. Mason, Chief Engineer, New England Public Service Co., Augusta, Maine (December, 1948). Member since 1931.

Louis A. Olney, Professor at the Lowell Textile Institute from 1897 to 1944, founder and first president of the American Association of Textile Chemists and Colorists, and recently elected president of Howes Publishing Co., died February, 1949, as a result of injuries in an auto-truck accident while on his way to spend a vacation in Florida. Dr. Olney was seventy-four and was known to his many students and friends as the "father of Lowell Textile." He had been a member for some years of the Sectional Committee on Textile Test Methods sponsored jointly by the A.A.T.C.C. and A.S.T.M.

JAMES B. THORPE, Vice-President, Climax Molybdenum Co., New York City (January 29, 1949). Member since 1929.

CHARLES H. WILSON, Chairman of the Board of Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., Bridgeport, Conn. (March 9, 1949). Mr. Wilson developed the industrial use of the Rockwell hardness tester for metals, engaging in its development and manufacture in 1920 in this country, and later introducing its use in other countries. He also developed pyrometers for measuring high temperatures in industrial processes, at first importing them from Europe but subsequently developing more advanced types of instruments, which in the first World War proved valuable in the manufacture of munitions and other war products. The Wilson Mechanical Instrument Co. has held company affiliation with A.S.T.M. since 1928.

J. MORLEY ZANDER, Autoclave Building Products Assn. (formerly Sand-Lime Brick Assn.), Saginaw, Mich. Representative of Association membership in A.S.T.M. since 1944, also on Committee C-15 on Manufactured Masonry Units where he rendered service on the Subcommittee on Concrete and Sand-Lime Units.

Notes on Laboratory Supplies

Catalog and Literature; Notes on New or Improved Apparatus

This information is based on literature and statements from apparatus manufacturers and laboratory supply houses.

Catalogs and Literature

Buehler Ltd., 165 W. Wacker Drive, Chicago 1, Ill. A four-page folder entitled "AB Cut-Off Machines for the Metallurgical Laboratory." Describes several different types including No. 1000 AB Abrasive Cut-Off Machine. No. 1010 AB Cut-Off Machine, a laboratory size cutting instrument with power for fast cutting of samples up to 1 in. in diameter; No. 1015 AB Cut-Off Machine offering the logical solution where space is of prime consideration in the laboratory because it is designed to stand on a work bench or table; No. 1016 AB Recirculating Cooling System eliminating the need of water and sewer connections; No. 1115 AB Specimen Cutter; No. 1116 AB Recirculating Cooling System; No. 1140 AB Specimen Cutter Assembly, and others.

The Emil Greiner Co., 20–26 N. Moore St., New York 13, N. Y. A 64-page catalog—"Constant Temperature Control"—a Manual for the Modern Laboratory and a Catalog of Requisite Equipment and Accessories. The need for constant temperature control devices of specialized design in physical, chemical, biological, etc., laboratories occurs with great frequency. The catalog covers fundamental principles, heaters and heating circuits, illustrates and describes Lolag and plug type immersion heaters; cartridge, ring type, and strip heaters; nichrome wire heaters; stirrers—light duty, air operated, etc.; circulating pumps; thermoregulators—Fenwal, "Quicket" bimetal, metastatic, "magna-set." Various types of relays are also described, and the catalog covers, in addition, control boxes, cylindrical baths, electrical accessories useful for constructing constant temperature equipment, etc. A detailed index is also included.

Arthur S. LaPine & Co., 121 W. Hubbard St., Chicago 10, Ill. Catalog M, entitled "Laboratory Supplies for Chemical, Clinical, Biological, Bacteriological, Metallurgical Laboratories," contains 416 pages describing general laboratory supplies, such as glassware, porcelain ware, filter papers, clamps, thermometers, supports, brushes, bottles, water baths, scales, filter pumps, hot plates, corks, hygrometers, rubber tubing, stoppers, etc. Profusely illustrated. Includes a detailed alphabetical index of all apparatus described in the catalog. It is indicated that this catalog is limited primarily to items which might be classified as expendable requirements necessary for the daily operation of the laboratory as distinct from capital equipment such as balances which are to be covered in another catalog now being prepared. Many of the instruments and supplies listed are used for A.S.T.M. specifications and tests. Page size, 8½ by 11 in.

The Baldwin Locomotive Works, Philadelphia 42, Pa. Bulletin 288 entitled, "Emery Hydraulic Cells," 8 pages, illustrates and describes the Emery Cells, the sensitive element in the weighing system of the A. H. Emery testing machine of 1879. Today's Emery Cells employ the same basic principle as the cell of 1879, with many improvements in design and construction, and special types have been developed for a wide variety of applications. The folder describes six standard models, ranging in capacity from 10,000 to 100,000 lb., and special cells having load capacities from 40 lb. to 2500 tons. The bulletin also describes three self-contained, portable weighing units or scales with Bourdon tube indicators and several cell applications with the still more accurate Tate-Emery indicator.

Wm. Hiergesell & Sons, 293 Pearl St., New York 7, N. Y. Bulletin 210, eight pages, illustrates and describes an extensive range of thermometers, including the large group covered in A.S.T.M. Specifications E 1. It further describes numerous paper scale, porcelain scale, and etched thermometers, including angle stem as well as the straight types. The company which has been manufacturing precision instruments since 1898, manufactures its standard range etched scale thermometers with red reading mercury or yellow glass.

Burrell Technical Supply Co., 1942 Fifth Ave., Pittsburgh 19, Pa. "Burrell Announcer of Scientific Equipment"—16 pages, illustrated. This publication is sent to a number of persons interested in advances and developments in the scientific field. It is sent free of charge, upon request, to any business address. The first issue has an interesting article on the evolution of modern glasses, descriptions of wide field microscopes, vacuum pressure regulator, a new Instru-Mount, and related items including a new direct reading Brinell hardness reader.

Will Corp., Rochester 3, N. Y. Bulletin No. 107 entitled "Laboratory Equipment" describes a laboratory lamp with four interchangeable lamp tubes for long and short ultraviolet, white and north sky quality light. Also included in the Bulletin are illustrations and descriptions of a new comparator set for Ehrlich urobilinogen determination, a portable electric direct-reading viscosimeter, hot air sterilizer, Will "Labspoons," etc. Four pages.

Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda 14, Md. A new ten-page bulletin, entitled "Description and Instructions on the Hunter Multipurpose Reflectometer," has just come off the press. This bulletin is intended as a detailed description and set of instructions, and contains much information about the Reflectometer not heretofore available. Chapters cover: application, the instrument, attachments and modifications, preparation for operation, operation, maintenance, and price list.

Instrument Notes

The Terg-O-Tometer—Model No. BD-101—Baker Instrument Co., 310 Main St., Orange, N. J. A device for simulation of home washers of the agitator type on a laboratory scale, evaluation of detergency, fastness of colors to laundering, redeposition of soil. The apparatus consists of a four-place unit in which the washing vessels and agitators are readily removable for convenience of operation and cleaning. The washing vessels are located in a thermostatically controlled water bath which will maintain a constant temperature of ±1 C. in the range of 25 C. to 100 C. The agitators are of the oscillating type, the speed of which may be varied between approximately 40 to 200 c.p.m. The speed is indicated by a tachometer located on the front of the apparatus. The agitators are a scale duplication of a leading make agitator type home washing machine.

Cenco Electroanalyzer—Central Scientific Co., 1700 Irving Park Road, Chicago 13, Ill. This is a six-position instrument of a new design in which the latest improvements have been incorporated for convenience in the quantitative separation of metals by electrolysis. The procedure for determination involves the depositing of pure metals on weighed platinum electrodes by electrolysis. The cabinet is constructed of welded steel with acid-resistant, wrinkle finish enamel. The unit is made corrosion-resistant, compact and sturdy, with an integral rectifier power supply built into the cabinet.

Multi-Outlet Strip—Eberbach & Son Co., Ann Arbor, Mich. This Multi-Outlet Strip provides six electrical outlets conveniently spaced 6 in. apart on a thin metal case; a rubber-covered cord and plug connects to permanent outlet. The M-O Strip is for use wherever additional electrical outlets are required. It is particularly useful in commercial and educational laboratories to eliminate the tangle of wires resulting from use of several multiple plugs at a single outlet; it eliminates the necessity for additional permanent wiring.

Fisher Power Supply—Fisher Scientific

Co., 717 Forbes St., Pittsburgh 19, Pa. This Power Supply is especially suited for use with the Beckman DU Spectrophotometer to provide extremely constant voltage from a storage battery. The Supply includes constant voltage regulator, rectifier, voltmeter, and ammeter. Instrument charges battery as current is used to operate tungsten light source, hydrogen light source or with flame attachment of spectrophotometer. Amount of charge can be varied so that potential supplied by battery is exactly the same from experiment to experiment. Voltmeter indicates condition of battery at all times and supply may be used as ordinary battery charger with 4-ampere capacity.

Also, the **Fisher Titer Tester—Fisher Scientific Co.** This Tester is used for carrying out the A.S.T.M. technique in determining solidification points of fatty acids. The apparatus is mechanized, employing a 100-rpm. motor to agitate the sample. Different chemists, working with identical equipment in different laboratories, can now follow the technique with assurance that the sample is being treated exactly as may have been reported in another laboratory—and the laborious job of stirring the sample exactly 100 times per minute is obviated. The Tester is a three-place apparatus, being furnished with three water baths, three air baths, six thermometers, sturdy cast-iron support base and shaker arms for transmitting oscillations of the motor to the samples.

Schiefer Abrasion Testing Machine—Sherman W. Frazier, 953 Fifteenth St., S. E., Washington 3, D. C. This machine is used in laboratory testing for resistance to abrasion. It was developed at the National Bureau of Standards in connection with a program of research on the abrasion resistance of textiles sponsored by the Office of the Quartermaster General. In this machine the specimen and abradant with their surfaces pressed together, rotate in the same direction and the same angular velocity but with their axes of rotation one inch apart. The outstanding features of the machine include: specimen mounting which permits removal of the specimen from the machine for examination and measurement during a test and return to the machine without disturbing the mounting; constant, adjustable tension on the specimen throughout the test; constant, adjustable pressure of abradant on the specimen throughout the test; novel abrasives for testing cloth which are essentially constant in their action for a period of use; uniform abrasive action applied from every azimuthal direction in the plane of the surface being tested. The machine was originally developed for testing textiles, but has been applied for testing paper, plastic films, and leather.

Electronic Fibrograph—Fulton Sylphon Division, Robertshaw-Fulton Controls Co., Knoxville 4, Tenn. This new Fibrograph cuts analysis time in cotton fiber tests to a few minutes, and gives an accurate, permanent record of the analysis.

Cartesian Manostat—Model No. 5—The Emil Greiner Co., 20–26 N. Moore St., New York 13, N. Y. Now in use in over 100 different industries, the automatic Cartesian Manostat, based on the principle of the Cartesian Diver, eliminates complicated electrical and mechanical systems or extra equipment of any kind.

Hellige Turbidimeter—Hellige, Inc., 3718 Northern Blvd., Long Island City 1, N. Y. This is for turbidity measurements, sulfate determinations, and general measurements of colloids and turbid suspensions. The apparatus measures 7 by 5 by 16 in. and is finished in a dull crystal black. It occupies only a minimum of space and may be used in any convenient place since no dark room is required. In addition to its application for measuring turbidity, the apparatus may also be employed for many analytical tests, usually accomplished by the Nephelometer. It is, therefore, equally suited for the measurement of colloids as well as of turbid suspensions.

Pyridinium Bromide Perbromide—Jasons Drug Co., 1085–87 Myrtle Ave., Brooklyn 6, N. Y. This new versatile brominating agent is now available, and is a stable solid, melting at 135 to 137 C. It can be used in glacial acetic acid, ethanol, and related solvents. Available bromine is 45–50 per cent. This material has shown excellent promise in replacing bromine in the Hanus Method for the determination of unsaturation and also in the separation of unsaturated acids from saturated acids.

Instrument Notes

Curve Reading Device—Koehler Instrument Co., 168-56 Douglas Ave., Jamaica 3, N. Y. This instrument was designed so that most of the movements ordinarily made by the eyes in reading spectrophotometric curves would be eliminated or greatly reduced by mechanical means. This was done by bringing into controlled juxtaposition the spectrophotometric curve, the wave-length scale, and the reflectance scale. The apparatus is portable. The platform carrying the graph sheet can be tilted to any angle convenient for reading and locked in place. All movements can be made with the left hand, leaving the right hand free to record data.

Leco Box Type Furnace—Laboratory Equipment Corp., St. Joseph, Mich. The LECO M-2900 box type laboratory furnace is designed for either high- or low-temperature operation. It has four large globar heating elements, custom built auto transformer, wide operational range, triple insulation, new type door, and sixty voltage adjustments.

Also, the LECO No. 2600 Combustion Tube Furnace—Laboratory Equipment Corp. This furnace is designed to operate at 2600 F. and above. The furnace insulated with about 6½ in. of insulating material around the heating chamber; it is housed in a heavy aluminum case. The operator is protected from all heating element electrical connections by side covers which are easily lifted off. Combustion tube clamps are adjustable to any size combustion tube up to 1½ in.

Stress-Strain Testing Machine—National Forge and Ordnance Co., Irvine, Warren County, Pa. This new testing machine of 5000 lb. capacity is used for determining the strength of containers. The rapidity with which it may be operated fits it especially for use in production line testing as well as for the testing laboratory. The specimen is placed on the lower platen and the upper platen is forced down upon it by motor-driven rotating screws. The compression strain is measured in pounds by a single lever balance and pendulum. The stress-strain reading is clearly visible on a large dial and there is also a pen-recorder that plots a five-magnification stress-strain diagram on a flat 8-in. by 10-in. chart.

NYLAB Titrator—New York Laboratory Supply Co., Inc., 76–78 Varick St., New York 13, N. Y. This new Titrator is used for electrometric titration procedures such as Karl Fischer, Oxidation-Reduction Acid-Base and Precipitation Methods. The titrator stand itself features built-in magnetic stirring, in which the activating magnet is contained within the beaker support. A line-operated, continuously reading dual purpose meter is supplied with the Nylab Titrator. The meter, having separate circuits and controls for the pH and the titration sections, can be used concurrently for pH and titration work. The Nylab Titrator operates from 115 volts, 50–60 cycles power supply only.

Pulverizer—Precision Scientific Co. 3737 W. Cortland St., Chicago 47, Ill. This pulverizer has been developed for grinding small samples from 3 to 20 g. It will reduce 4- or 8-mesh material to 50-mesh screen or finer. The Pulverizer has been used to grind a wide variety of materials of varying hardness: rock salt, activated alumina, marble chips, Pyrex, quartz. To grind a 5-g. sample takes only one to four minutes, depending upon the hardness of the material. The apparatus is essentially a small high-speed hammer mill with fixed hammers. The rotor is made of Stellite and other parts are made of hardened steel. Loss or contamination of the sample is negligible. The body of the apparatus is mounted on a shaft between two side plates so that it can be pivoted upside down for easy cleaning.

Gyco Heating Jackets—Scientific Glass Apparatus Co., Inc., Bloomfield, N. J. A new feature of these jackets is the addition of a small thermostat in the circuit within the insulation. This thermostat, permanently sealed against vapors or moisture, automatically opens the circuit when the jacket temperature reaches approximately 370 C. The life of the heating elements is greatly prolonged, since they always operate at a safe level well below the glow point.

Also, Vanderkamp "Melt-Pointer"—Scientific Glass Apparatus Co., Inc. This new apparatus is for the determination of melting points of chemicals, waxes, fats, etc. It consists of three parts: body, chamber block, and adapter. The upper section or block is carefully machined of solid copper. A thermometer and three capillaries are held in position in the center of the chamber by an adapter plug. The lower portion or body of the apparatus houses, in addition to the cartridge heaters, a small 110-volt light bulb below a window for the illumination of the interior of the chamber. This "Melt-Pointer" has a temperature range to over 400 C. No liquids or mechanical stirring units are required. Rapid continuous tests may be made; extra blocks are available permitting use of one as another cools; apparatus is easily stored in a drawer and is instantly ready for use in plugging in the electrical connections.

Bench Model Ductility Testing Machines—Steel City Testing Machines, Inc., 8843 Livernois Ave., Detroit 4, Mich. This new model machine for testing the drawing qualities of sheet metal is very compact (only 2 ft. 11 in. in height and 26 in. across) and has an exceptionally fast cycle. Speed of piston travel is adjustable within a wide range by means of a simple dial setting. Complete tests in as little as 15 seconds are possible. The machine is built with a capacity of 15,000 lb. to cup test material up to ⅝ in. in thickness or 30,000 lb. for material up to ¼ in. in thickness. This new model is motorized and hydraulically operated.

"Aluminum"

By R. L. Templin[1]

EDITOR'S NOTE.—This paper is essentially the one presented by President Templin at meetings sponsored by various A.S.T.M. Districts. His presentation was modified somewhat, depending on the arrangements in the various districts, for example, the New York meeting was a joint one with the Machine Design Division of The American Society of Mechanical Engineers, and he included more data on this phase of aluminum. In his presentation he used quite a large number of interesting slides and a representative selection of the illustrations appear in this paper. The following districts held a President's Night at which Mr. Templin spoke: Washington (D. C.)(Oct. 14, 1948); Chicago (Oct. 19); Philadelphia (Nov. 10); Cleveland (Nov. 16); New York (Feb. 3, 1949); Detroit (Feb. 21); New England (April 14) (Boston). At meetings in Los Angeles (March 15) and San Francisco (March 25), sponsored by the Southern and Northern California Districts, Mr. Templin spoke on the subject, "The Determination and Significance of the Mechanical Properties of Metals."

THE geologists tell us that about eight per cent of the earth's crust is aluminum. We know that it is widely disseminated throughout the world and is so tightly combined with other elements that its separation from them is difficult. Although Oersted first separated a tiny bit of the metal in 1825, Wöhler a larger amount in 1845, and Deville was able to produce a bar of it to exhibit at the Paris Exhibition in 1855; yet a practical commercial process for producing the metal was not discovered until 1886. During that year the same process was discovered at about the same time by two scientists of the same age, working independently. Heroult in France and Hall in this country arrived at the same electrolytic process. This coincidence was further emphasized by the fact that both men died the same year.

Although the potential ores of aluminum are numerous, the one currently used is bauxite. This ore comprises aluminum oxide combined with water plus a number of impurities. It occurs in a variety of colors and in a wide range of hardness. The more important deposits in this country are in Arkansas. Ore from this location together with a considerable amount of ore from Surinam is refined in this country.

The ore is mined by both the open-pit and shaft-tunnel methods depending on the proximity of the deposits to the surface. After mining, the ore is crushed and dried. It is then subjected to a chemical refining process wherein it is digested with caustic soda. This process dissolves the hydrated aluminum oxide, leaving the impurities to be separated by settling and filtration. Pure aluminum hydrate is then precipitated from the filtered solution, washed to remove the caustic soda, and dehydrated at very high temperature to remove the combined water. The resulting product is a white powdery chemical compound, aluminum oxide (Al_2O_3), commonly called alumina. This material is then electrolytically reduced to aluminum. About five pounds of ore are required to make two pounds of alumina, from which is obtained one pound of aluminum. To do this, however, it is necessary to use about a pound of carbon electrode and about 10 kw-hr. of electricity plus some cryolite, so altogether it takes about twelve tons of raw materials to produce one ton of the metal.

Aluminum has a number of interesting qualities. It is light in weight, being about one-third the weight of iron, copper, or brass. It has good thermal and electrical conductivity, yet is nonmagnetic. It has good resistance to corrosion, reflects light and radiant heat very effectively, it is nontoxic and nonsparking, and quite similar to silver in appearance. It is readily workable and has a high scrap and re-use value.

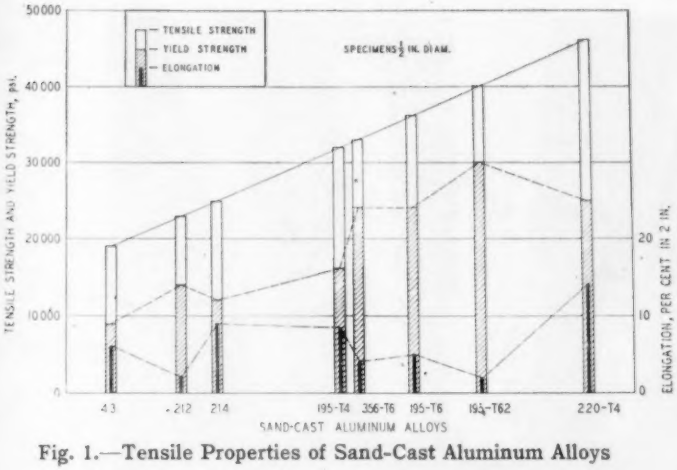


Fig. 1.—Tensile Properties of Sand-Cast Aluminum Alloys

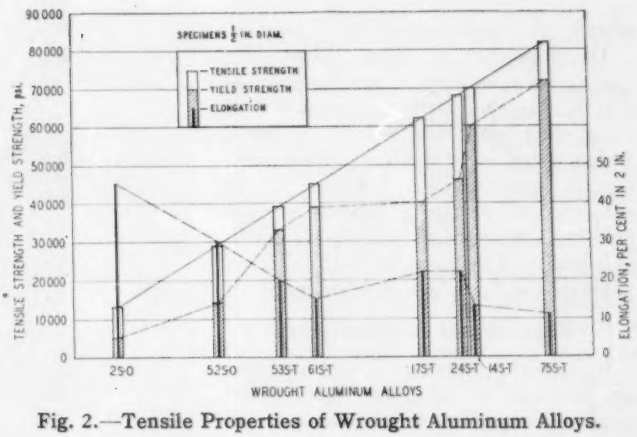


Fig. 2.—Tensile Properties of Wrought Aluminum Alloys.

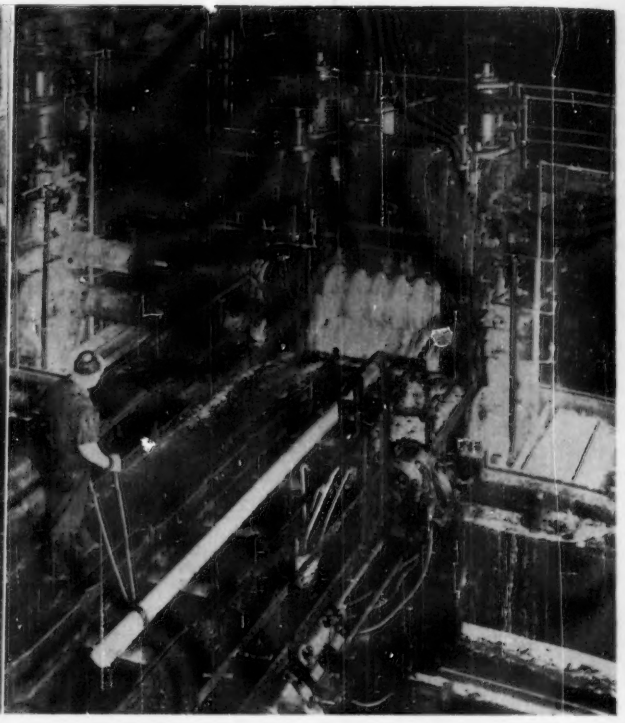
ALLOYS

Although pure aluminum has mechanical properties suitable for many uses, these properties can be varied over wide ranges by cold working, alloying with other metals, and by heat treatment. The variations in tensile and yield strength obtainable, for example, are indicated in Figs. 1 and 2, for aluminum alloys in both the cast and wrought conditions.

The other metals commonly used in aluminum alloys include copper, silicon, nickel, iron, magnesium, manganese, chromium, and zinc. These metals are alloyed with aluminum for the purpose of improving the mechanical properties and changing other characteristics such as the chemical and electrical properties, so that the products made from the

[1] President, American Society for Testing Materials; Assistant Director of Research and Chief Engineer of Tests, Aluminum Company of America, New Kensington, Pa.

Forging an Aluminum Alloy Propeller Blade.



Rolling Structural Aluminum Alloy Shapes.

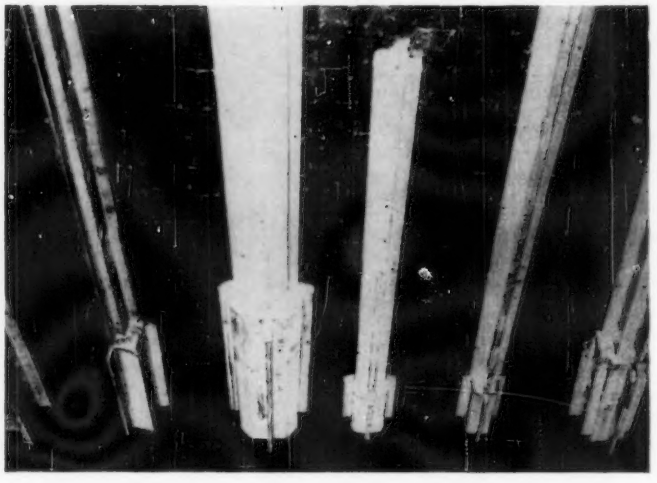
alloys will give satisfactory service.

Development of new alloys for specific purposes is a continuing research, together with improvement of production and fabrication methods. Before a new alloy is released for experimental exploitation, however, it is subjected to extensive laboratory and field tests designed to indicate the probable utility of the material in the various fields of use for which it is intended.

Fabrication of Aluminum

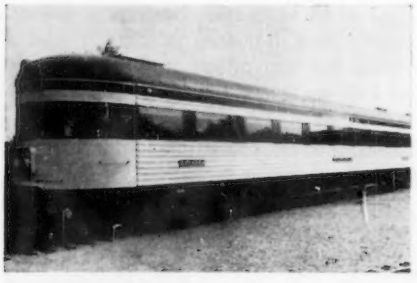
In general, aluminum commodities are produced or fabricated using processes quite similar to those used for commodities of other metals and alloys.

Castings are made in sand, permanent molds, and dies. Forgings are produced using drop, steam, or air hammers; or hydraulic and crank presses.

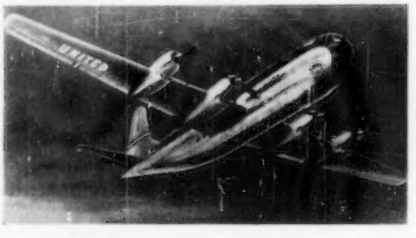


Aluminum Alloy Stepped Extrusions for Aircraft Wing Spars.

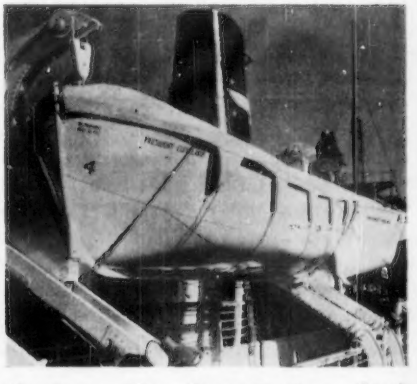
For aluminum castings, lower temperatures are required than for iron or steel, but to make aluminum alloy forgings, larger hammers and presses are necessary.



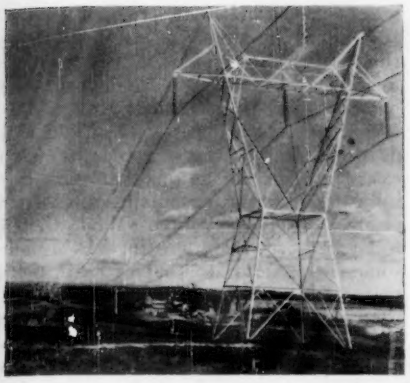
Aluminum Superstructure Railroad Passenger Car with Alumilite Exterior Moldings.



Boeing Stratocruiser C-97.



Aluminum Alloy Superstructure, Stack Enclosures, Lifeboats and Davitts on S. S. President Cleveland of U. S. President Lines, 1947.



Aluminum Conductors Reinforced with High Strength Steel (ASCR) 795 000 cm., 220 kv.

Pennsylvania Water and Power Co., 1931.

Aluminum sheets, plates, bars, rods, and shapes are rolled on mills similar to those used for working other metals, except that the aluminum alloys require greater forces to work at the temperatures used and hence the mills are larger or have larger motors. Aluminum tubes, shapes, rods, and wire are drawn with equipment quite similar to that used in drawing copper, brass, and steel commodities. Extruded shapes are made using equipment and procedures like those used in the copper and brass industries. Furthermore, the other metal-working operations such as stamping, coining, pressing, bending, forming, etc., for aluminum are quite similar to those used for copper, brass, and steel. Many aluminum articles and structural units have been and are being made, using fabricating equipment and tools originally intended for the same operations on other metals.

Aluminum Products or Commodities

Aluminum products or commodities are available in nearly all of the forms commercially obtainable in other metals. Some limitations in sizes, however, will be found in certain products, such as large structural shapes and thicker plates. These size limits are imposed by ingot size, press or rolling mill capacity, flattening equipment, heat treating facilities, and other factors. The limitations undergo changes from time to time so that the maximum or minimum dimensions of today may be different tomorrow.

PERCENTAGE SHIPMENTS TO VARIOUS INDUSTRIES BY ALUMINUM COMPANY OF AMERICA.

	1947	1948
Building products	19	18
Transportation (all forms)	15	13
Cooking utensils	9	9
Machinery (electrical and general)	6	4
Household appliances	7	9
Power transmission	6	6
Fabricators for further processing	24	25
All other uses	14	16
	100	100

Uses of Aluminum

There are over 4000 uses of aluminum today and new applications occur constantly. It is therefore impossible, in any brief discussion, to cover all the uses. Most of the applications can be grouped into a few rather broad fields as shown in the accompanying table, and some idea of the extent of the use of aluminum may be obtained from the tonnage going to each of the groups. While these data apply specifically to shipments made by the Aluminum Company of America, they should still be indicative of the extent of use of aluminum in the fields shown.

Aluminum Collapsible Tubes.

Aluminum Paint as Applied to the San Francisco Bay Bridge.

According to the Department of Commerce, the U. S. production of semifinished aluminum products in 1947 was 1,850,000,000 lb. Of this total, 1,400,000,000 lb were wrought products and 450,000,000 lb were castings. Production of primary (new) aluminum by the whole U. S. industry in 1948, according to The Aluminum Association, was 1,245,000,000 lb.

A number of examples of aluminum applications are shown in the accompanying illustrations.

These examples will no doubt suggest other applications for the metal and its various product forms. Nationally we are confronted with the problem of producing more aluminum in order that the present demands for it may be met.

It is interesting to note that, according to F. W. Clarke, while aluminum, iron, and magnesium account for about 15 per cent of the earth's crust, the total proportion of copper, zinc, and lead is only about 0.016 per cent. While these facts probably cause us no immediate concern, yet they suggest that future generations of necessity will have to use more aluminum.

Life Blood of Industry—du Pont Research

THE Philadelphia *Inquirer* of Tuesday, January 4, under a special heading "Life Blood of Industry" published a pertinent article entitled "Du Pont Supports Research to Maintain Its Position," prepared by Dr. E. K. Bolton, Director, Chemical Dept., E. I. du Pont de Nemours & Co. This article will undoubtedly be of interest to all A.S.T.M. members concerned with research, and it is reprinted below with the permission of Dr. Bolton and the *Inquirer*. Dr. Bolton is an A.S.T.M member, representing the du Pont A.S.T.M. Sustaining Membership. He has been a leader in his field, and has received many honors and awards.

"The du Pont company believes in research because it is the only means by which the company can maintain its present position in the highly competitive chemical industry, and because the new products and processes which will determine the company's future can be developed only through research.

"The public also benefits from this work of course, because products and processes having their origin in the Nation's research laboratories have helped raise the American standard of living far above that ever enjoyed by any people in the world.

NEW INDUSTRIES RESULT

"Among a host of other benefits, research has given rise to countless new products which have given birth to new industries and created thousands of jobs. About 30 per cent of du Pont's sales, for example, are currently in products that either did not exist or were not in commercial production in 1936. The manufacture and sale of these products alone is giving employment to 20,000 men and women.

"In addition, research has resulted in better wages. Through the development of improved manufacturing processes, this scientific 'tool' has brought about greatly increased production, which goes hand in hand with higher wages.

"Du Pont's recently announced program for a $30,000,000 expansion of research facilities at the experimental station in Wilmington, Del., affords abundant proof of the company's faith in research. The main purpose of these new laboratories is to provide facilities for work that will be reflected in new and useful products for the consumer, and for the discovery of new fundamental knowledge that may serve as the basis for further developments.

GREATER COMPETITION

"One manifestation of this increased scientific activity will be competition in the chemical field of a degree never before experienced. We may expect to see many products which have met with public favor fall by the wayside and displaced either by similar but lower-priced products or by wholly new, and better products.

"In this period of keen competition, the chemical industry will not only continue to rely on the universities for the fundamental information so necessary to industrial research, but also will increase its own efforts to create new basic knowledge. It was partly with this in mind that du Pont entered upon the expansion of its own research facilities."

Measurement of Radioactive Isotopes

RADIOACTIVE isotopes are today finding an increasing number of uses and it is important to determine accurately the number of radioactive atoms in a radioactive sample. However, uniform quantitative results can be obtained by different laboratories only through the use of techniques that will yield absolute measurements or by comparison with certified standards. Detailed directions for use of radioactive standards and calibrated samples of radioisotopes issued by the National Bureau of Standards are given in a new 12-page pamphlet entitled *Measurement of Radioactive Isotopes*, now available as National Bureau of Standards Circular 473.

In correlating measurements of radioisotopes in different laboratories, the Bureau distributed identical samples of radioactive materials to approximately 40 hospitals, universities, and similar institutions. The range of values reported by these laboratories varied as much as 80 per cent from the average. Because radiations are emitted equally in all directions, it is practically impossible to devise detecting equipment to record all of them. This and other difficulties encountered are discussed in some detail in the booklet, and directions are given for overcoming them. Among the topics treated are basic principles of measurement, units, the use of radioactive standards, preparations of working standards, and corrections for change in radioactivity with time.

NBS Circular 473 by Leon F. Curtiss, can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 5 cents a copy.

Magnetic Measurement of Composite Copper-Nickel Coatings

A CONVENIENT, nondestructive magnetic method for determining the thickness of composite copper-nickel coatings electrodeposited on steel has been developed by Abner Brenner and Eugenia Kellogg of the National Bureau of Standards. The method involves the measurement of the attractive force between the plated specimen and two permanent magnets of different strengths. The values thus obtained are used, in conjunction with a set of previously determined calibration curves for each magnet, to obtain the total thickness of the coating and the relative thicknesses of the copper and nickel layers.

Composite coatings, in which nickel is deposited over a layer of copper, are used extensively in the automotive and other industries for the economical protection of steel against corrosion. While the effectiveness of these coatings is usually somewhat inferior to that of pure nickel plate, the copper required is less expensive than the extra layer of nickel that would otherwise be necessary. As the protective value of the composite coatings depends largely on their thickness, it is important to have a convenient means for measuring this property. In the usual procedure, the plated article must be destroyed to provide a cross-section for microscopic examination. The new magnetic method, on the other hand, eliminates the necessity of cutting the specimen and is easily and rapidly applied.

This method utilizes the principle of the Magnegage, an instrument originally designed at the Bureau to measure the thickness of single electro deposited coatings on the basis of the attraction between a small permanent magnet and the plated sample. The Magnegage is essentially a spring balance, on the arm of which a magnet is suspended in contact with the coated surface. A helical spring is so attached that, when wound by means of a knob, it exerts a force tending to detach the magnet from the surface. If, as is ordinarily the case, the coating is less magnetic than the object plated, the required force, as indicated on a dial adjacent to the knob, will be greater for thinner coatings.

For measurement of composite coatings, the Magnegage is modified by the use of two magnets of different strengths. A set of calibration curves for each magnet—total thickness *versus* dial readings—are plotted on transparent material for coatings of successively varying known proportions of copper and nickel. After readings are taken with each magnet on the composite coating under study, one set of calibration curves is superposed on the other in such a way that the values of the two separate dial readings on the horizontal scale for each magnet are brought into coincidence. A straight line is drawn joining points of intersection of curves of the same percentage composition. If a second line is then drawn, perpendicular to the horizontal scales of the graphs, through the point representing the dial readings, it will intersect the first line in a point corresponding to the thickness of the total coating. The relative thicknesses of the copper and nickel layers are also obtained by graphical interpolation along the line joining the intersection points of the curves of equal composition.

In this way, total thicknesses of composite coatings ranging from 0.0005 to 0.003 in. can be determined within about 10 per cent. The thickness of each component layer of similar coatings can be measured to an accuracy of about 15 per cent.

Application of the Radioactive Tracer Technique to Metal Cleaning

By J. C. Harris,[1] R. E. Kamp,[1] and W. H. Yanko[1]

METAL cleaning, like other cleaning, is an art because there is no real measure of "how clean is clean." For certain purposes a "clean" surface may be one free from an undesired contaminant but coated with a corrosion-preventive compound. For others a minimum of any sort of contaminant is the goal. Such factors determine that each job classification shall have its own specification, nor is this outside the realm of reality by any means.

Although each job has its own cleanliness requirement, there should be suitable methods available for determining whether "clean" surfaces are being obtained. While there are a few qualitative methods for such determinations in use, experience concerning the effect upon subsequent processing probably is the one most relied upon.

From the plant to the laboratory is a step from the quasi-quantitative to what might be expected as a fully quantitative evaluation. Under laboratory conditions it is possible more nearly to approach strict control and quantitative measure, but even here there is need for means of measuring "cleanliness."

Much has been written[2] concerning laboratory evaluation and the methods used for quantitatively measuring the degree of soil removal. These methods are water-break or some variant, subsequent treatment in an electroplating bath, quantitative degreasing (whether gravimetric or colorimetric), and utilization of ultraviolet light technique (luminograms or fluorescence measurement of degreased, cleaned panels or the degreasing fluid). Most of these methods prove useful for control purposes, but all possess some inherent inadequacy.

The availability of radioactive compounds has opened the field for measurement of trace amounts of materials, and this technique appeared to offer considerable promise in metal-cleaning studies. The purpose of this paper is to indicate the utility of this method as applied to metal cleaning.

Choice of Radioactive Element:

Since the usual soil used in laboratory evaluation of metal cleaners is a lubricating oil, it would be preferable that any additive used for indicating soil should be of a similar type. The chemical reactivity or stability of the tracer compound should be of the same order as shown by petroleum hydrocarbons. The half-life of the radioactive element used should permit a storage period of sufficient length, and the element selected should permit ready synthesis of the desired organic compound. Selected for these reasons was C 14, a soft beta-emitter of very long half-life (5300 yr.).

Synthesis of Radioactive Compound:

Preliminary evaluation indicated that N,N-di-*n*-butyl stearamide was soluble in S.A.E. No. 60 oil, and could be synthesized in adequate yield with good purity. The chemical reactions involved are:

$$C_{17}H_{35}COOAg + Br_2 \rightarrow C_{17}H_{35}Br + CO_2 + AgBr \quad (1)$$

$$C_{17}H_{35}Br + Mg \rightarrow C_{17}H_{35}MgBr \quad (2)$$

$$C_{17}H_{35}MgBr + C^{14}O_2 \rightarrow C_{17}H_{35}C^{14}OOMgBr \quad (3)$$

$$C_{17}H_{35}C^{14}OOH + SOCl_2 \rightarrow C_{17}H_{35}C^{14}OCl + SO_2 + HCl \quad (4)$$

$$C_{17}H_{35}C^{14}OCl + 2(n\text{-}C_4H_9)_2NH \rightarrow C_{17}H_{35}C^{14}ON(C_4H_9)_2 + (C_4H_9)_2NH\cdot HCl \quad (5)$$

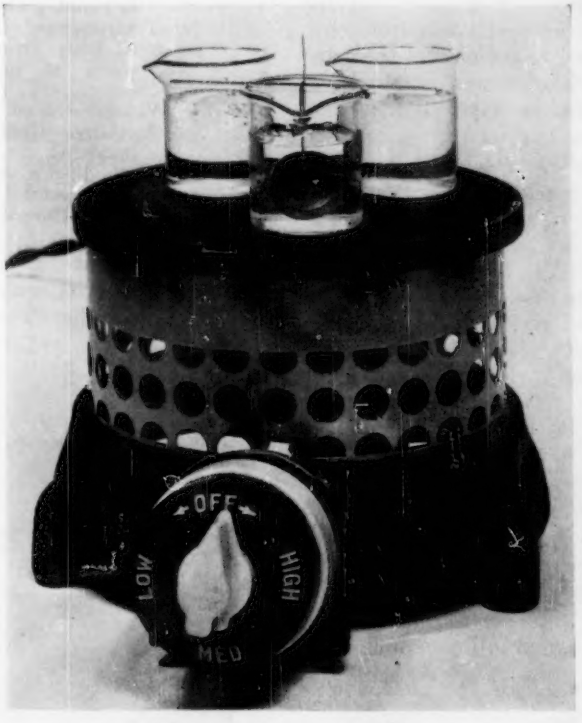


Fig. 1.—Cleaner Assembly.

SOILING PROCEDURE

Panels:

The pans or panels used were circular and had an over-all diameter of 1 in. The pan size was restricted to the diameter of the mica window of the Geiger-Müller counter tube. They resembled pans in that they were drawn to a depth of $\frac{1}{16}$ in. with a $\frac{1}{32}$-in. rim. At one point in the rim a small hole

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Central Research Department, Monsanto Chemical Co., Dayton, Ohio.

[2] J. C. Harris, "Metal Cleaning II—Soil Removal Performance Methods," ASTM BULLETIN, No. 136, October, 1945, pp. 31–39.

was drilled to permit vertical suspension during cleaning or drying. The pans were vapor degreased in carbon tetrachloride prior to soiling, dried under an infrared lamp and stored in a desiccator prior to use. Immediately before soiling, each pan was weighed and counted for background.

Soiling Mixture:

The stearamide produced contained 6.63 microcuries of C 14 per mg. of material. When a thin sample was counted with the Geiger-Müller counter (2.2 mg. per sq. cm. mica window) an activity of 4×10^5 counts per min. per mg. was obtained.

It was arbitrarily decided that each pan should have an initial activity of 10^5 counts per min., and it was determined by trial that 25 mg. of soil (S.A.E. No. 60 oil plus the substituted radioactive stearamide) would adequately cover the pan. On this basis 99 mg. of oil plus 1 mg. of stearamide provided enough soil for four pans at the desired level of activity. Carbon tetrachloride was used as solvent for the radioactive N,N-di-*n*-butyl stearamide. The required volume of solution was added to the oil and then the carbon tetrachloride was removed by evaporation before application of the soil to the pan.

Application to Pans.—The active mixture was applied with a thin glass rod about 2 mm. in diameter. Use of a rod of this size permitted the rather viscous material to be applied in small increments and also facilitated the even distribution of the material over the pan. By adding the soil a little at a time and then weighing, the desired value of 25 mg. was very closely approached, and with practice the number of weighings was reduced to a minimum.

The mixture was well stirred before each application, since even though it appeared quite homogeneous, experience indicated some degree of settling of the radioactive material on standing.

Metal Cleaning Procedure

The essentials of the method follow:

Soil:

1. Kind—97 per cent S.A.E. No. 60 oil (Standard Oil Co. of Ohio); 1 per cent N,N-di-*n*-butyl stearamide; 2 per cent Fluorescent Green H. W. (Wilmot and Cassidy, Inc., Brooklyn, N. Y.).
2. Application—See below and "Application to Pans" above.

Cleaning Technique:

1. Metals:
   (*a*) Surface-hardened sheet steel—No. 32 gage.
   (*b*) Stainless steel—No. 28 gage.
2. Panel Size:
   (*a*) Disks, 1 in. in diameter.
3. Solution:
   (*a*) Detergent—5 per cent Santomerse No. 1; 95 per cent anhydrous sodium metasilicate.
   (*b*) Concentration—5 per cent by weight in distilled water.
   (*c*) Volume—35 to 40 ml.
   (*d*) Temperature—Rolling boil.
   (*e*) Time—5 min.
   (*f*) Agitation—See *d*.

   See Fig. 1 for cleaning assembly.

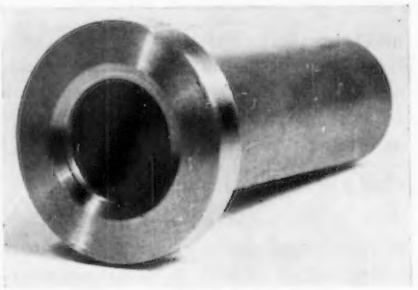


Fig. 2.—Geiger-Müller Tube.

4. Rinsing:
   (*a*) Solution—Two in distilled water; one in running tap water.
   (*b*) Time—Six dips into each hot rinse; approximately 60 sec. in running rinse.
   (*c*) Temperature—Distilled water at boil; running cold tap water at tap temperature (about 50 F.).
   (*d*) Volume—50 ml. distilled water
   (*e*) Agitation—Rolling boil or as indicated.
   (*f*) Method—See above.
5. Drying: Suspended under infrared lamp until completely dry.

Assay of Pans

Equipment.—The equipment consists of a Geiger-Müller Tube with mica window 2.4 mg. per sq. cm. (Fig. 2), scaler with scale of 64 and timer (Fig. 3), and sample holder (Figs. 4 and 5).

To accomplish the dual purpose of holding the tube and adjusting the geometry of the system a sample[3] holder was made. This sample holder (Figs. 4 and 5) is essentially a spring-loaded platform that can be lowered so as to insert the sample and then raised to place it next to the window. It was necessary to provide a light shield for the window as the tube used was extremely photosensitive.

Corrections.—Not all the corrections[4] to which radioactive measurements are subject were applied in the metal-cleaning work discussed. Elimination of most of the corrections was possible because the method was used as a "null point" method, that is, the goal was 100 per cent cleanliness and no attempt was made to calculate per cent soil removal. If it were necessary to show soil removal as a percentage term, the true initial count would be required and the corrections must then be applied.

Sensitivity.—The approximate limit of sensitivity attainable gravimetrically is 5×10^{-5} g., but the usual sensitivity is 1×10^{-4} g. Using the tracer technique the sensitivity is approximately 2×10^{-9} g. per sq. cm. as illustrated below:

[3] M. I. Kamen, "Radioactive Tracers in Biology," Academic Press, Inc., p. 174 (1947).

[4] D. Wright Wilson, A. O. C. Nier, and Stanley P. Reimann, "Preparation and Measurement of Isotopic Tracers," J. W. Edwards, Ann Arbor, Mich., pp. 83–108 (1947).

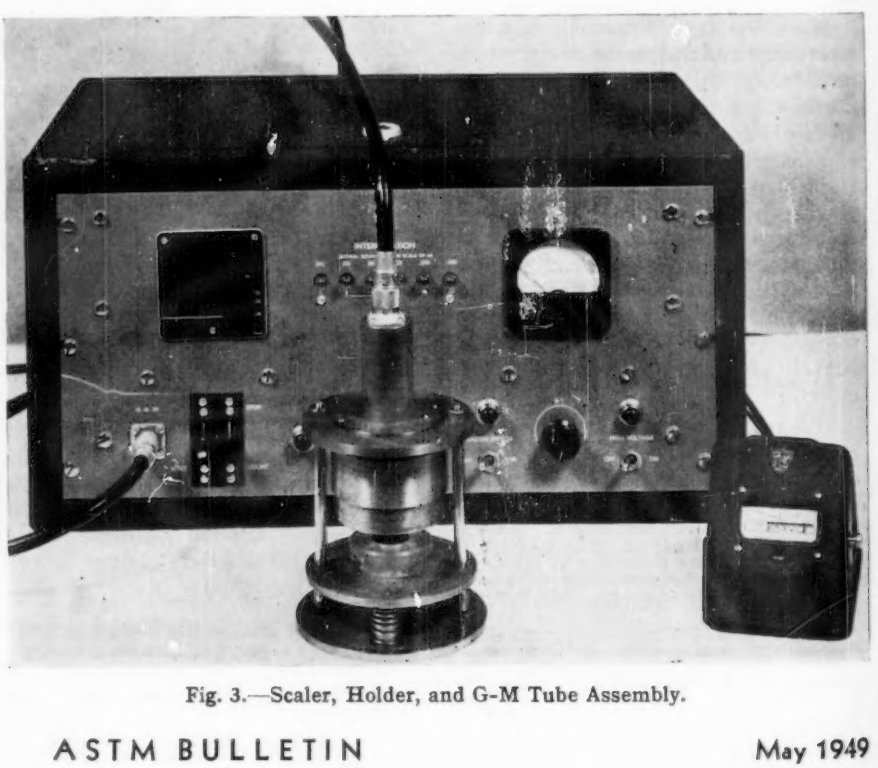


Fig. 3.—Scaler, Holder, and G-M Tube Assembly.

Pan 13 (Table II) had a final count of 2 after the fourth wash.

Initially it was contaminated with 25 mg. of soil which gave a true count of 10^5 counts per min. (See "Soiling Mixture" under "Soiling Procedure.")

Then,

$$\frac{\text{2 counts per min. (final)}}{10^5 \text{ counts per min. (initial)}} = \text{fraction of soil remaining}$$

and

$$\frac{\text{2 counts per min.}}{10^5 \text{ counts per min.}} \times \frac{\text{25 mg. soil (initial)}}{\text{2.26 sq. cm. (area of pan)}} = 2 \times 10^{-9} \text{ mg. soil per sq. cm.}$$

This figure does not take into consideration the statistical variation in the count which in this case would approximate $\pm 1 \times 10^{-9}$.

Evaluation of Method

Pans cleansed could be evaluated gravimetrically for increase or decrease in weight, by weighing residual oil obtained by subsequent degreasing, observation under ultraviolet light source for fluorescence of the dye used in the soil, and finally by the present method for measurement of soil. With such small test panels, water-break methods did not prove applicable.

Gravimetric estimation of retained soil gave negative results. Degreasing methods showed no retained soil, and fluorometric estimation of the plate and of the degreasing liquid gave no indication of retained dye. Table I shows data indicating that after subtraction of background count, counts still remained at least double to quadruple the background, indicating an "unclean" condition. With gravimetric methods sensitive to 5×10^{-5} g. and the present method to 2×10^{-9} g. per sq. cm., it is not entirely unexpected that residual soil might be found. There are, however, other explanations for this residual count. The explanation which seems most reasonable is that chemisorption occurred. It will be recalled that substituted amines are used as acid inhibitors and are preferentially adsorbed. A substituted amide under alkaline conditions might readily exhibit the phenomenon of adsorption.

Since "soil" remained on the plate as indicated by radioactivity, attempts were made by repeated washing to entirely remove it. Table II shows that the background (or zero) count was attained in from three to five repeated washings, indicating that the preferential adsorption theory would best seem to account for residual radioactivity.

An experiment was conducted to determine whether a clean pan would be contaminated with the radioactive amide present in a used cleaning bath. Following the rinsing cycle this pan gave a count within the background range which further strengthens the chemisorption theory.

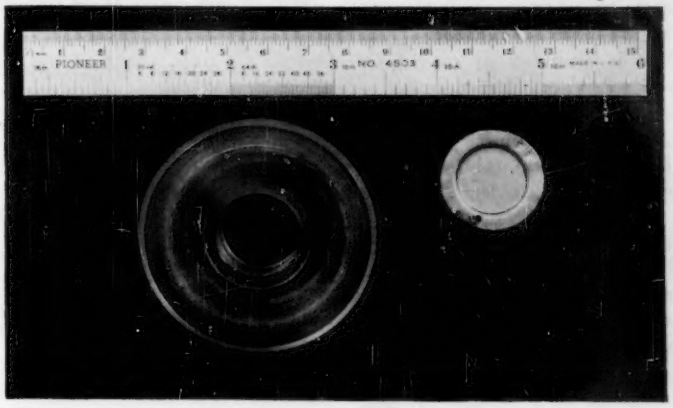


Fig. 4.—Plastic Platform and Pan.

Using steel pans it was virtually impossible to prevent some degree of rusting. When stainless steel pans were substituted this difficulty was obviated. The results of this test are shown in Table III. It is apparent here that multiple washings also were necessary, but that background count was reached about one wash sooner than with steel. Again, this would seem to substantiate the chemisorption explanation for retained activity.

A residual count of 275 after the first wash would be the equivalent of 45×10^{-6} g. of total soil, or 0.45×10^{-6} g. of radioactive amide, both of which are beyond the sensitivity of the gravimetric method of estimation.

On this basis then, and since the plates are "clean" so far as previously used methods would indicate, the present method of estimation can readily be used, provided that care is taken to use essentially the same amount of initial soil and to control the washing technique.

Criticism of Method

The N,N-di-*n*-butyl stearamide chosen tends to segregate upon standing. Preferential adsorption of this compound also appears to occur.

The small size of the pan makes it difficult to apply recognized nondestructive tests such as water-break, or fluorometric examination, or destructive tests such as degreasing (and gravimetric measurement of residue), electrodeposition, or removal of fluorescent dye for colorimetric measurement.

Steps are already under way to correct segregation and preferential adsorption of the radioactive tracer compound. The use of equipment which would accommodate larger pans would reduce error inherent to the use of small samples.

Summary

The test outlined requires the use of a radioactive tracer compound compatible with an oily soil and it should not be preferentially removed or adsorbed. The technique used in handling the C 14 containing compound is standard for the use of radioactive materials. The equipment required for counting is a Geiger-Müller tube, scaler, and timer. A correction for background was applied, and a constant geometry maintained throughout the counting procedure to obviate the necessity for other corrections, and the system was

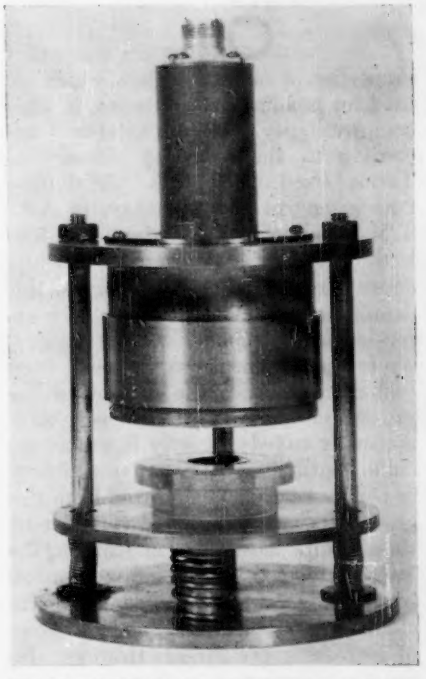


Fig. 5.—G-M Tube, Platform and Light Shield (Upper Ring).

TABLE I.—SURFACE-HARDENED SHEET STEEL—SINGLE WASH.

Sample	Initial Count	Count After First Wash[a]
No. 13.....	31 800	80
No. 14.....	31 572	58
No. 15.....	32 752	102
No. 16.....	32 331	49

[a] Subtract 25 for background correction.

used essentially as a null indicator. Thus the minimum count after correction then is assumed as maximum soil removal, or practical cleanliness.

Evaluation of N,N-di-*n*-butyl stearamide as a tracer compound indicates that it possesses the undesirable properties of separation from the oily soil, and that it is preferentially adsorbed. A tracer compound intended to correct these faults is being synthesized.

Any remaining soil is present in amounts not detectable by gravimetric measurement, no fluorescent dye (also used in the soil) remains, and an apparent sensitivity of 2×10^{-9} g. per sq. cm. is obtained.

Evaluation of the method indicates that the tracer compound can probably be successfully used in evaluation of cleaning compositions, though a hydrocarbon-like tracer compound not liable to chemisorption is necessary for absolute measurement.

The radioactive tracer technique applied to metal cleaning is more sensitive than existent methods for estimation of soil removal, is quantitative in character, and appears to be a distinct advance in this art.

Acknowledgment:

The assistance and encouragement given by J. W. Heyd and I. B. Johns are acknowledged with gratitude. We are indebted to Sarah J. Aulebaugh for the photographs shown.

TABLE II.—SURFACE-HARDENED SHEET STEEL—MULTIPLE WASH.

Sample	Initial Count	Count After[a]			
		First Wash	Second Wash	Third Wash	Fourth Wash
No. 13.....	31 800	80	44	35	27
No. 14.....	31 572	58	38	28	..
No. 15.....	37 952	102	63	52	42
No. 16.....	32 331	49	32	32	28

[a] Subtract 25 for background correction.

TABLE III.—STAINLESS STEEL—MULTIPLE WASH.

Sample	Initial Count	Count After[a]			
		First Wash	Second Wash	Third Wash	Fourth Wash
No. 21.....	34 212	212	54	33	27
No. 22.....	37 707	243	42	25	..
No. 24.....	38 599	278	60	26	..

[a] Subtract 25 for background correction.

A Compressibility Test for Metal Powders

By F. V. Lenel[1]

One of the important properties of metal powders, which are used for molding and sintering is their compressibility. Compressibility according to the proposed glossary of Terms Used in Powder Metallurgy, now in course of preparation in A.S.T.M. Committee B-9 on Metal Powders, is the degree of attainment of absolute density in pressing. According to this definition compressibility should be expressed in per cent of absolute density. Up to the present it has, however, been customary to give the density of the pressed sample—its green density as it is usually called—directly in grams per cubic centimeter. The compressibility in per cent may be calculated from this green density simply by dividing it by the absolute density and multiplying the fraction by 100. Complete compressibility data for a given powder should include green densities obtained at a series of increasing pressures. However, for practical purposes it is often found sufficient to measure the compressibility at only one pressure, which is near the pressure used for molding parts from the given powder in actual production.

Compressibility determinations have been customary in the laboratories of powder producers and parts fabricators. However, no standardized test method had been developed up to the time when Subcommittee II on Metal Powders of Committee B-9 became interested in this test method. The principle of the test method is very simple. A weighed quantity of metal powder is compacted in a die under a given pressure. The compacted sample is ejected from the die, its volume is determined by measuring its dimensions accurately, and its density is calculated by dividing its weight in grams by its volume in cubic centimeters. The density of a compact prepared by this method will depend not only upon the pressure applied and the properties of the powder but also upon a number of other factors, the most important of which are:

The size and shape of the compact.
The method of load application.
The rate of load application.
The surface finish of the compacting die.
The method of lubricating the die.

It is comparatively easy to standardize the first three of these factors. The size and shape factor can be eliminated by selecting a definite size and shape of test specimen. A choice can be made between applying load from one end only or applying load from both ends and specifying in which sequence the load should be applied from the two ends. A definite rate of load application can be specified. It is much more difficult to eliminate the influence of the last two factors. When members of the Metal Powder Subcommittee discussed the compressibility tests customary in their laboratories, it became clear that different lubricants and different methods of applying these lubricants were used in different laboratories and that very few quantitative data existed on the influence of various lubricants upon either the absolute values of compressibility or the reproducibility of compressibility data from test to test. It was therefore decided to study the influence of various lubricants upon compressibility in a cooperative test program. It was hoped that a standard test method for testing compressibility could be based on the results of this program. Although this hope was not realized, the results of the program and their critical evaluation seem to be of

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sufficient interest to warrant making them generally available.

Test Program

The simplest solution to the problem of lubrication would be to make the compressibility test without any lubricant, but this is not possible because of the danger of scoring the die wall. In industrial practice it is customary to add the lubricant to the powder mixture either as a dry powder or dissolved in a solvent. In a standard compressibility test it would, however, be preferable to lubricate only the die walls in order to avoid complications in standardizing on the grade and the quantity of lubricant added, the time and the method of mixing, etc. It was therefore agreed to compare the following five methods of lubrication:

1. Lubrication of the die barrel with S.A.E. 30 oil.
2. Lubrication of the die barrel with oleic acid.

TABLE I.—TOOLS USED IN COMPRESSIBILITY TEST.

Laboratory	Material of Die Barrel	Inside Diameter of Die Barrel, in.	Finish of Die Barrel	Radial Clearance Between Die Barrel and Punches
1	Crocar	½	Lapped finish	0.0005 in.
2	Ketos, R_c 63	½	Longitudinal scratches expected from 4 yr. use	Sliding fit estimated 0.001–0.002 in. Center diameter cross-section larger than end diameter cross-section by possibly 0.001 in.
3	Tungsten carbide insert in steel	½	Excellent finish on die barrel, 15 microin.	0.0002 in.
4	Ketos or Paragon	½	Fine grinding following hardening, mold in average condition for operation involving a metal powder and abrasive mixture	Punches slide freely 0.0005–0.0015 in.
5	Halcomb, high carbon–high chrome	½	Lapped ½ in. on end of die barrel tapered, region of briquetting straight	0.0003 in.
6	Oil-hardening tool steel, R_c 61–62	½	Finish ground, taper 0.0005 in. per in. of 1½ in. cavity, new die never used before this test	0.00075 in.
7	Steel	½	Very smooth surface, small bell mouth, both ends	0.0015
8	Tungsten high-speed steel	1	Smooth grind finish. No taper	0.00035 in.
9	Air-hardening die steel, 0.33 C, 3.5 Ni, 1.5 Cr, 0.20 Mo	⅝	Cylindrical punch 2–9 microin., three scores in die barrel, but minor in area used in compacting	Lower punch 0.0002 in.; upper punch 0.003 in.

TABLE II.—DENSITY OF GREEN COMPACTS MOLDED IN DIE LUBRICATED WITH S.A.E. 30 OIL.

Laboratory	Copper Powder A			Copper Powder B			Copper Powder C		
	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density
1	5	7.61 to 7.63	7.62	5	7.51 to 7.52	7.52	5	7.55 to 7.57	7.56
2	5	7.62 to 7.65	7.63	5	7.50 to 7.58	7.55	5	7.54 to 7.58	7.56
3	3	7.58 to,7.61	7.59	4	7.40 to 7.49	7.45	3	7.48 to 7.52	7.51
4	7	7.57 to 7.62	7.59	7	7.42 to 7.58	7.49	7	7.29 to 7.56	7.43
5	5	7.58 to 7.62	7.61	5	7.50 to 7.52	7.51	5	7.45 to 7.52	7.50
6	Lubricating action reported insufficient[a]								
7	3	7.57 to 7.61	7.59[a]	3	7.54 to 7.58	7.56[a]	5	7.35 to 7.51	7.42[a]
8	5	7.51 to 7.56	7.54	5	7.45 to 7.46	7.46	5	7.54 to 7.55	7.55
9	1	7.10+	7.10[b]	1	7.38	7.38[a]	1	7.36	7.36[a]
Range of averages	..	7.54 to 7.63 (0.09)	..	..	7.38 to 7.56 (0.18)	..	..	7.36 to 7.56 (0.20)	..
Grand average	34	7.596	..	35	7.500	..	36	7.496	..

Laboratory	Iron Powder D			Iron Powder E			Iron Powder F		
	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density
1	5	6.32 to 6.35	6.34	5	5.69 to 5.73	5.71	5	5.68 to 5.72	5.70
2	5	6.40 to 6.47	6.44	5	5.81 to 5.85	5.83	5	5.75 to 5.78	5.76
3	3	6.28 to 6.36	6.31	3	5.78 to 5.82	5.80	3	5.74 to 5.77	5.75
4	7	6.35 to 6.50	6.38	7	5.76 to 5.80	5.78	7	5.74 to 5.77	5.76
5	5	6.33 to 6.34	6.34	5	5.74 to 5.78	5.77	5	5.68 to 5.70	5.69
6	Lubricating action reported insufficient[a]								
7	3	6.36 to 6.48	6.43[a]	2	5.82 to 5.83	5.82[a]	0[a]	...	..
8	5	6.40 to 6.41	6.40	5	5.75 to 5.76	5.75	5	5.76 to 5.77	5.77
9	1	6.25	6.25[a]	1	5.68	5.68[a]	1	5.61	5.61[a]
Range of averages	..	6.25 to 6.44 (0.19)	..	..	5.68 to 5.83 (0.15)	..	..	5.61 to 5.77 (0.16)	..
Grand average	34	6.374	..	33	5.772	..	31	5.735	..

[a] Severe chatter observed in stripping compacts from the die lubricated with S.A.E. 30 oil.
[b] Compact seized in die, this value not included in range of averages and grand average.

TABLE III.—DENSITY OF GREEN COMPACTS MOLDED IN DIE LUBRICATED WITH OLEIC ACID.

Laboratory	Copper Powder A			Copper Powder B			Copper Powder C		
	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density
1	5	7.67 to 7.68	7.68	5	7.56 to 7.57	7.56	5	7.59 to 7.61	7.60
2	5	7.65 to 7.68	7.67	5	7.57 to 7.59	7.58	5	7.59 to 7.60	7.60
3	..	No data	..	..	No data	..	..	No data	..
4	..	No data	..	..	No data	..	..	No data	..
5	5	7.64 to 7.66	7.65	5	7.49 to 7.52	7.51	5	7.51 to 7.52	7.51
6	6	7.52 to 7.57	7.55	7	7.48 to 7.51	7.53	7	7.52 to 7.54	7.53
7	1	7.73	7.73	1	7.65	7.65	1	7.65	7.65
8	..	No data	..	..	No data	..	..	No data	..
9	1	7.56	7.56	1	7.54	7.54	1	7.53	7.53
Range of averages	..	7.55 to 7.73 (0.18)	..	..	7.51 to 7.65 (0.14)	..	..	7.51 to 7.65 (0.14)	..
Grand average	23	7.630	..	24	7.548	..	24	7.560	..

Laboratory	Iron Powder D			Iron Powder E			Iron Powder F		
	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density
1	5	6.49 to 6.51	6.50	5	5.88 to 5.90	5.89	5	5.82 to 5.84	5.83
2	5	6.53 to 6.54	6.54	5	5.92 to 5.96	5.94	5	5.88 to 5.92	5.89
3	..	No data	..	..	No data	..	..	No data	..
4	..	No data	..	..	No data	..	..	No data	..
5	5	6.45 to 6.46	6.46	5	5.88 to 5.89	5.88	5	5.81 to 5.83	5.82
6	6	6.31 to 6.51	6.39	6	5.79 to 5.82	5.80	6	5.79 to 5.82	5.80
7	1	6.59	6.59	1	6.01	6.01	1	5.93	5.93
8	..	No data	..	..	No data	..	..	No data	..
9	1	6.46	6.46	1	5.92	5.92	1	5.94	5.94
Range of averages	..	6.39 to 6.59 (0.20)	..	..	5.80 to 6.01 (0.21)	..	..	5.80 to 5.94 (0.14)	..
Grand average	23	6.473	..	23	5.882	..	23	5.842	..

3. Lubrication of the die barrel with pump grease.
4. Lubrication of the die barrel with a dispersion of colloidal graphite.
5. Lubrication by mixing the powder with a solid lubricant and compacting it in an unlubricated die.

It was not found practical to specify a definite finish of the die to be used in the tests because of the excessive cost of preparing special dies. Instead it was suggested that whatever die was on hand should be used, but that information on the die used should be supplied.

Nine laboratories participated in the test program, the details of which were worked out by the author. Three copper powders and three iron powders were tested. All the powders were taken from regular production lots, each coming from a different manufacturer. To insure that each of the laboratories would receive identical samples, the following procedure was used for each of the six powders. Fifty pounds of powder were taken from one drum as supplied by the manufacturer and blended for thirty minutes in a barrel mixer. Three-pound samples for each of the cooperating laboratories were taken from this 50-lb. blend. Each laboratory received, therefore, six cans of powder; the three samples of copper powder were designated as *A*, *B*, and *C*, the three samples of iron powder were designated as *D*, *E*, and *F*. Each can of copper powder was sealed with wax after a small bag of drying agent had been added in order to minimize oxidation during transit and storage, while the cans of iron powder were left unsealed. Instruction sheets on how to proceed with the test were supplied to each laboratory. The instruction sheet is shown in Appendix A.

Results

The results of the tests are shown in Tables I to VI. Table I summarizes the information on the condition of the compacting tools as supplied by the cooperating laboratories. The density data obtained with the five recommended lubricants are given in Tables II to VI. Some data on other lubricants were also reported, but as they were not markedly superior to the five recommended lubricants either in the general level or in uniformity they were not tabulated. Difficulties with some of the lubricants were reported as follows: Build-up of graphite and sticking were mentioned by three of the six cooperators who used or attempted to use colloidal graphite as a lubricant. Of the nine cooperators who used or attempted to use S.A.E. 30 oil as a lubricant, three reported difficulties with chattering during stripping and with seizing. One out of six reported difficulties with pump grease because of insufficient lubricating action.

Discussion

Comparing the grand averages for the five lubricants it will be seen that in the case of the copper powders, the data with oleic acid and pump grease as lubricants are somewhat higher than those with oil, colloidal graphite, and a solid lubricant. In the case of the iron powders the results with a solid lubricant are higher and those with oil as lubricant are lower than the results with oleic acid, pump grease, and graphite as lubricants. Lubricants which produce high values in the compressibility test or in other words show superior lubricating action would in general be preferable to those showing less favorable lubricating action. However, high absolute values are much less important for a satisfactory test method than good reproducibility from laboratory to laboratory. Most laboratories show variations of less than 0.5 per cent within each series of tests. Variations as high as 1 per cent are observed only in a few cases, usually those where difficulties with the lubricant in question were encountered. However, variations between laboratories are much higher. The differences between the lowest and the highest average density amount to 2 to $3\frac{1}{2}$ per cent for all powders and lubricants. The question arises as to what factors cause these variations. A study of the tabulated data may throw some light on this question. Considering the data on individual lubricants it will be found that frequently one or two laboratories show results which deviate markedly from the average. Laboratory No. 4, for instance, reports high values for grease lubrication, laboratory No. 3, which used calcium stearate instead of zinc stearate, reports low values for solid lubricant and also for graphite lubrication and laboratory No. 9 reports low values for oil lubrication. It seems probable that these deviations for individual lubricants should be ascribed to differences in the grade of lubricants or differences in the technique of applying the lubricant, rather than to differences in the compacting tools. Averaging the results on all the lubricants it will be found that only one laboratory, No. 7 in the tabulation, has results consistently higher than the average and one, No. 6, has results consistently lower than the average. A comparison of the data on tools of these two laboratories with those of the other laboratories does not clearly

TABLE IV.—DENSITY OF GREEN COMPACTS MOLDED IN DIE LUBRICATED WITH PUMP GREASE.

Laboratory	Trade Name of Grease	Copper Powder A			Copper Powder B			Copper Powder C		
		Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density
1	Temprite	5	7.68 to 7.70	7.69	5	7.57 to 7.60	7.59	5	7.61 to 7.62	7.61
2	Mobilgrease No. 6	5	7.60 to 7.64	7.62	5	7.52 to 7.56	7.54	5	7.55 to 7.57	7.56
3	Sovarex No. 1	3	7.67 to 7.70	7.68	3	7.52 to 7.55	7.53	3	7.53 to 7.57	7.55
4	Temprite	7	7.72 to 7.76	7.73	7	7.63 to 7.70	7.66	7	7.65 to 7.68	7.67
5	Mobilgrease No. 6	5	7.62 to 7.65	7.63	5	7.53	7.53	5	7.51 to 7.56	7.54
6	Mobilgrease No. 6	7	7.39 to 7.62	7.54	7	7.48 to 7.51	7.50	7	7.52 to 7.55	7.53
7	.....	..	No data	..	..	No data	..	..	No data	..
8	.....	..	No data	..	..	No data	..	..	No data	..
9	.....	..	No data	..	..	No data	..	..	No data	..
Range of averages	.....	..	7.54 to 7.73 (0.19)	..	..	7.50 to 7.66 (0.16)	..	..	7.53 to 7.67 (0.14)	..
Grand average	.....	32	7.645	..	32	7.560	..	32	7.591	..
		Iron Powder D			Iron Powder E			Iron Powder F		
1	Temprite	5	6.37 to 6.40	6.38	5	5.77 to 5.87	5.80	5	5.78 to 5.81	5.80
2	Mobilgrease No. 6	5	6.48 to 6.50	6.49	5	5.85 to 5.90	5.87	5	5.83 to 5.86	5.84
3	Sovarex No. 1	3	6.43 to 6.58	6.50	3	5.89 to 5.91	5.90	5	5.73 to 5.88	5.82
4	Temprite	7	6.56 to 6.58	6.57	7	5.97 to 6.01	6.00	7	5.92 to 5.99	5.94
5	Mobilgrease No. 6	5	6.45 to 6.49	6.47	5	5.85 to 5.87	5.86	5	5.76 to 5.80	5.79
6	.....	Lubricating action reported insufficient								
7	.....	..	No data	..	..	No data	..	..	No data	..
8	.....	..	No data	..	..	No data	..	..	No data	..
9	.....	..	No data	..	..	No data	..	..	No data	..
Range of averages	.....	..	6.38 to 6.57 (0.19)	..	..	5.80 to 6.00 (0.20)	..	..	5.79 to 5.94 (0.15)	..
Grand average	.....	25	6.488	..	25	5.890	..	27	5.846	..

indicate any differences which may have caused the higher and the lower results, and the variations in these two cases may quite possibly also be due to differences in technique rather than in the tools.

Standard Test Method

When the subcommittee on metal powders reviewed the results of the test program in February, 1948, the results sticking of the compacts in the die are to be expected when oil is used as a lubricant, and the attempt to write a tentative test method based upon oil as a lubricant was therefore abandoned.

Before further attempts are made to devise a standard method for a compressibility test, further work seems necessary. Most of the difficulties with regard to reproducibility are evidently due to the frictional effects between powder and die wall. In order to minimize these effects it may be necessary to choose a test compact with a larger diameter having a more favorable ratio of volume to wall area. Larger presses than those generally available are necessary to compress such compacts and this is the reason why ½-in. diameter compacts were chosen for the test program. On the other hand better reproducibility may be obtainable by a further careful study of all the variables involved in making the test, including cross checks of compacting dies between laboratories.

TABLE V.—DENSITY OF GREEN COMPACTS MOLDED IN DIE LUBRICATED WITH COLLOIDAL GRAPHITE SUSPENSION.

Laboratory	Copper Powder A			Copper Powder B			Copper Powder C		
	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density
1	5	7.62 to 7.65	7.64	5	7.46 to 7.51	7.48	5	7.44 to 7.57	7.50
2	5	7.62 to 7.66	7.64	5	7.51 to 7.53	7.52	5	7.55 to 7.57	7.56
3[a]	4	7.14 to 7.49	7.38	1	7.37	7.37	Not used—graphite build-up in die		
4	..	No data	..	..	No data	..	..	No data	..
5[b]	5	7.52 to 7.56	7.54	5	7.45 to 7.48	7.46	5	7.45 to 7.48	7.46
6	Lubricating action reported insufficient								
7[c]	5	7.63 to 7.69	7.65	5	7.56 to 7.58	7.57	5	7.57 to 7.62	7.60
8	..	No data	..	..	No data	..	..	No data	..
9	..	No data	..	..	No data	..	..	No data	..
Range of averages	..	7.38 to 7.65 (0.28)	..	..	7.37 to 7.57 (0.20)	..	..	7.46 to 7.60 (0.14)	..
Grand average	24	7.578	..	21	7.501	..	20	7.530	..

Laboratory	Iron Powder D			Iron Powder E			Iron Powder F		
	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density
1	5	6.52 to 6.54	6.53	5	5.91 to 5.95	5.93	5	5.86	5.86
2	5	6.53 to 6.55	6.53	5	5.91 to 5.93	5.93	5	5.87 to 5.91	5.88
3	Not used because of graphite build-up in die								
4	..	No data	..	..	No data	..	..	No data	..
5[b]	5	6.31 to 6.36	6.32	5	5.71 to 5.73	5.72	5	5.69 to 5.71	5.70
6	Lubricating action reported insufficient								
7[c]	5	6.42 to 6.47	6.45	5	5.87 to 5.98	5.94	5	5.87 to 5.90	5.89
8	..	No data	..	..	No data	..	..	No data	..
9	..	No data	..	..	No data	..	..	No data	..
Range of averages	..	6.37 to 6.53 (0.21)	..	..	5.72 to 5.94 (0.22)	..	..	5.70 to 5.89 (0.19)	..
Grand average	20	6.457	..	20	5.880	..	20	5.832	..

[a] Used 1 part Aquadag, 2 parts alcohol.
[b] Used 1 part Dag Dispersion No. 154, 15 parts alcohol.
[c] Used 1 part Aquadag, 15 parts alcohol, reported chatter in stripping.

TABLE VI.—DENSITY OF GREEN COMPACTS MADE OF POWDERS MIXED WITH 1 PER CENT SOLID LUBRICANT BEFORE MOLDING

Laboratory	Solid Lubricant	Copper Powder A			Copper Powder B			Copper Powder C		
		Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density
1	Zn stearate	5	7.65 to 7.67	7.66	5	7.55	7.55	5	7.61 to 7.62	7.62
2	Zn stearate	5	7.54 to 7.58	7.55	5	7.45 to 7.48	7.46	5	7.48 to 7.49	7.48
3	Ca stearate	3	7.52 to 7.54	7.53	3	7.38 to 7.42	7.40	3	7.33 to 7.38	7.35
4	.....	..	No data	..	..	No data	..	..	No data	..
5	Zn stearate	5	7.60 to 7.61	7.60	5	7.46 to 7.48	7.47	5	7.50 to 7.52	7.51
6	Zn stearate	7	7.54 to 7.59	7.56	7	7.48 to 7.50	7.49	7	7.50 to 7.54	7.53
7	Zn stearate	5	7.70 to 7.72	7.71	5	7.56 to 7.59	7.58	5	7.60 to 7.61	7.61
8	Zn stearate	5	7.60 to 7.64	7.61	5	7.50 to 7.52	7.51	5	7.57 to 7.58	7.58
9	.....	..	No data	..	..	No data	..	..	No data	..
Range of averages	.....	..	7.53 to 7.71 (0.18)	..	..	7.40 to 7.58 (0.18)	..	..	7.35 to 7.62 (0.27)	..
Grand average	.....	35	7.605	..	35	7.499	..	35	7.536	..

Laboratory	Solid Lubricant	Iron Powder D			Iron Powder E			Iron Powder F		
		Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density	Number of Samples	Range of Density	Average Density
1	Zn stearate	5	6.51 to 6.53	6.52	5	5.92 to 5.94	5.93	5	5.86 to 5.88	5.87
2	Zn stearate	5	6.56 to 6.64	6.59	5	6.01 to 6.02	6.02	5	5.92 to 5.94	5.93
3	Ca stearate	3	6.39 to 6.45	6.41	3	5.98 to 6.00	5.99	4	5.76 to 5.87	5.80
4	.....	..	No data	..	..	No data	..	..	No data	..
5	Zn stearate	5	6.52 to 6.53	6.53	5	5.96 to 5.98	5.97	5	5.83 to 5.86	5.84
6	Zn stearate	7	6.42 to 6.50	6.47	7	5.87 to 5.90	5.89	7	5.79 to 5.88	5.83
7	Zn stearate	5	6.57 to 6.61	6.59	5	6.01 to 6.03	6.02	5	5.87 to 5.90	5.89
8	Zn stearate	5	6.54 to 6.61	6.58	5	6.00 to 6.05	6.02	5	5.91	5.91
9	.....	..	No data	..	..	No data	..	..	No data	..
Range of averages	.....	..	6.41 to 6.59 (0.18)	..	..	5.89 to 6.02 (0.13)	..	..	5.80 to 5.93 (0.13)	..
Grand average	.....	35	6.531	..	35	5.971	..	36	5.867	..

Acknowledgments:

The author wishes to thank the following persons who through their cooperation made the test program possible:

C. J. Hardy, Charles Hardy, Inc., New York, N. Y.
L. S. Busch, P. R. Mallory and Co., Inc., Indianapolis, Ind.
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Appendix A: Instruction Sheet

1. The die assembly used for the compressibility test shell consists of a cylindrical die barrel and two punches. The punches shall be long enough so that they protrude from the ends of the die barrel after the test sample has been briquetted.

Note 1.—A 0.500 ± 0.010-in. inside diameter die barrel is recommended; if a larger or a smaller die barrel is used, the weight of powder must be adjusted as shown under (2).

Note 2.—No recommendation is made as to material and finish of the die and the fit between die barrel and punches. However, complete information on these items should be supplied in the questionnaire.

2. 10.0 ± 0.1 g. of powder, or of the mix in the case where a mixture of powder and lubricant is pressed, should be used as a sample in a ½-in. (inside diameter) die.

Note.—If a die barrel larger or smaller than 0.500 ± 0.010 in. is used, the weight of the powder sample should be $(x/0.500)^3 \times 10$ g., where x is the inside diameter of the die in inches. For example, if the I.D. of the die is 0.600 in. the weight of the powder sample should be $(0.600/0.500)^3 \times 10 = 17.3$ g. In this way the ratio of diameter to length or the ratio of pressing area to wall area of the samples is held constant regardless of the actual dimension of the diameter.

3. The following five methods of lubrication for the compressibility test have been suggested:

- Lubrication of the die barrel with S.A.E. 30 oil.
- Lubrication of the die barrel with oleic acid.
- Lubrication of the die barrel with pump grease.
- Lubrication of the die barrel with a dispersion of colloidal graphite.
- Lubrication by mixing the powder with a solid lubricant and briquetting in an unlubricated die.

It is recommended that tests with as many of these methods of lubrication as feasible be performed in each of the cooperating laboratories. In addition, you are urged to make tests with other methods of lubrication which have been found advantageous in your laboratory and report the method and the results obtained.

4. The following method for lubricating the die with S.A.E. 30 oil is recommended: A piece of rayon cloth 8 by 6 in. is wetted with oil by dropping a few drops of oil from an oil can onto the cloth and then rubbing the cloth until the oil wets as much of the cloth as possible. The procedure is repeated until the entire cloth is just wetted. The cloth is not oily, but somewhat similar to a damp (wetted with water) cloth. The original oiling is sufficient for several compressibility determinations. If the cloth feels too dry, a few drops of oil are added as described above. The cloth wetted with oil is pushed manually through the die barrel three times by a thin rod. No lubricant is applied to the punches.

5. The method described in (4) is also recommended for lubricating the die with oleic acid.

6. "Temprite" made by the Alemite Corporation and "Mobile Grease No. 6" made by Socony-Vacuum Corporation have been used for compressibility tests with grease lubrication of the die. Other pump greases may also be satisfactory. The method of applying the grease used in this Laboratory consists in depositing a small amount of grease at one opening of the die barrel and distributing the grease by means of pushing a cloth through the die barrel. The grade of grease and the method of applying it should be noted in the Questionnaire.

7. Dag dispersion No. 154 of Acheson Colloids Corp. diluted at a ratio of 1 part of No. 154 to 2 parts of denatured ethyl alcohol is recommended. This dispersion of colloidal graphite in alcohol takes the place of the dispersion of graphite in carbon tetrachloride which has been discontinued by Acheson Colloids. The die barrel is lubricated by closing one end with one finger, filling it with the lubricant and letting the lubricant flow out by removing the finger. Care should be taken that all the diluent is evaporated before powder is poured into the die barrel. The evaporation might be accelerated by blowing air through the die barrel, but the air stream should not be so strong that part of the graphite is also blown out. Between each test the die barrel has to be carefully cleaned so that no residual graphite is left in the die barrel.

8. One per cent of zinc stearate is recommended as a solid lubricant which is mixed with the powder. The mixture is briquetted in an unlubricated die. The method of mixing used in this Laboratory consists in weighing out 100 g. of powder and 1 g. of zinc stearate and pouring them in a square 250-ml. mixing bottle, shaking the bottle vigorously, screening the mixture through an 80-mesh screen using a brush in order to break up any lumps; returning the screened mix to the mixing bottle and mixing it in a mixer. The mixer has a horizontal axis of rotation, the bottle being held in six cages inclined 45 deg. toward the horizontal. The mixer rotates 50 rpm. and the mixture is mixed for 15 minutes.

9. The load is to be applied from both ends by means of the following arrangement. With the lower punch inserted into the die barrel, the die barrel is supported by spacers. The powder is poured into the die barrel, the upper punch is inserted, and a preliminary pressure of 5000 psi. is applied to the upper punch, while the die barrel is supported by the spacers; then, the pressure is released and the spacers are removed. With the spacers removed, the final briquetting pressure of 60,000 psi. is to be applied. The actual load in pounds is to be computed from the I.D. in inches of the die barrel by means of the formula:

$$\text{Load in pounds} = \text{pressure in psi.} \times (\text{I.D.})^2 \times \pi/4$$

Note.—The thickness of the spacers will depend upon the length of the punches used, but in any case they should be high enough so that the lower punch is still protruding from the die barrel after the pressing operation is finished. The same spacers should be used for all tests so that the powder is always briquetted in the same part of the die barrel.

10. The rate of load application should be 60,000 psi. per min. This rate should be controlled by a rate-of-loading device where the testing machine is equipped with such a device. If no such device is available, the load should be applied at as even a rate as possible, so that the full load is reached in one minute.

11. As soon as the maximum load is reached, the pressure should be released ("Zero dwell").

12. The briquetted samples are to be pushed out of the die barrel by taking out the lower punch, setting the die barrel on spacers and applying pressure to the upper punch either in the press used for briquetting, or in an arbor press.

13. It is recommended that at least five samples, and if possible more, be briquetted for each powder and method of lubrication.

14. If the samples have burrs on the ends, these burrs are to be removed by rubbing them lightly on fine emery paper before measuring and weighing the samples.

15. The length and diameter of each sample in inches are to be carefully measured with micrometers to the nearest 0.0001 in. If the samples are out-of-round or tapered, enough measurements must be taken so that the mean diameter and the mean length of each sample can be determined by averaging.

16. The sample is to be weighed to the nearest 0.002 g.

17. The green density of each sample is to be calculated to the nearest 0.01 g. per cu. cm. from its length, diameter, and weight by the formula

$$\text{Density in g. per cu. cm.} = \frac{\text{weight, g.}}{(\text{diam., in.})^2 \times \text{length, in.}} \times 0.07770$$

18. The following method of presenting the data obtained is recommended:

COPPER POWDER A

	Individual Densities, g. per cu. cm.	Average Density, g. per cu. cm.	Range of Densities, g. per cu. cm.
Lubricant: S.A.E. 30 oil (See Questionnaire—question 2)			
Lubricant: Oleic acid (See Questionnaire—question 3)			
Lubricant: Grease (See Questionnaire—question 4)			
Lubricant: Colloidal graphite (See Questionnaire—question 5)			
Lubricant mixed with powder (See Questionnaire—question 6)			
Other lubricant (See Questionnaire—question 7)			

COPPER POWDER B
(same as above)

Effect of Speed of Testing on the Tensile Properties of Austenitic Stainless Steel Sheets

By R. H. Heyer[1]

In 1937, Subcommittee V on Mechanical Testing of A.S.T.M. Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys undertook a study of the effect of speed of testing on the tensile properties of austenitic stainless steels. Over a period of five years data were submitted by committee members and others showing the effect of speed of testing on wire, standard round, and flat specimens. It became evident that testing speed had a marked effect on test results but that no simple relationship to mechanical properties could be established. The metallurgical instability of the grade was recognized as an important factor influencing the results. Speed of testing was found to be more critical for thin, flat specimens than for round.

In 1942 a cooperative testing program was undertaken by laboratories of the following companies:

The American Rolling Mill Co., Middletown, Ohio,
Carnegie-Illinois Steel Corp., Chicago, Ill.,
Dow Chemical Co., Midland, Mich.,
The International Nickel Co., Bayonne, N. J., and
Union Carbide and Carbon Research Labs., Niagara Falls, N. Y.

Three standard 2-in. gage length specimens of each of seven grades were prepared by one laboratory and triplicate specimens were tested by each of the laboratories using "the proper testing procedure for the specification involved." (See Table I and Figs. 1 to 3 for results.)

Three laboratories used crosshead speeds which gave nominal strain rates in the gage length of approximately 0.20 in. per in. per min. One laboratory used a much lower strain rate and obtained high strength and elongation for all grades except type 430, a ferritic stainless steel which is not speed sensitive.

The most speed-sensitive grade tested was type 301 (Figs. 1 and 2), followed by types 304, 321, and 347 (Fig. 3). The ferritic grade type 430 (Fig. 3) was included as a check on the general accuracy of the testing machines. The average tensile strength values are within a range of ±2.1 per cent for this material.

The 1942 program showed that widely divergent results could be expected in tests made under the existing specifications. The product specifications did not designate testing speeds, but referred to A.S.T.M. Methods E 8 for tension testing procedure.[2] At that time Methods E 8 included the statement: "When the tensile properties of a material are appreciably affected by speed of straining, suitable limits for rate of straining should be included in the purchase specifications covering that material."

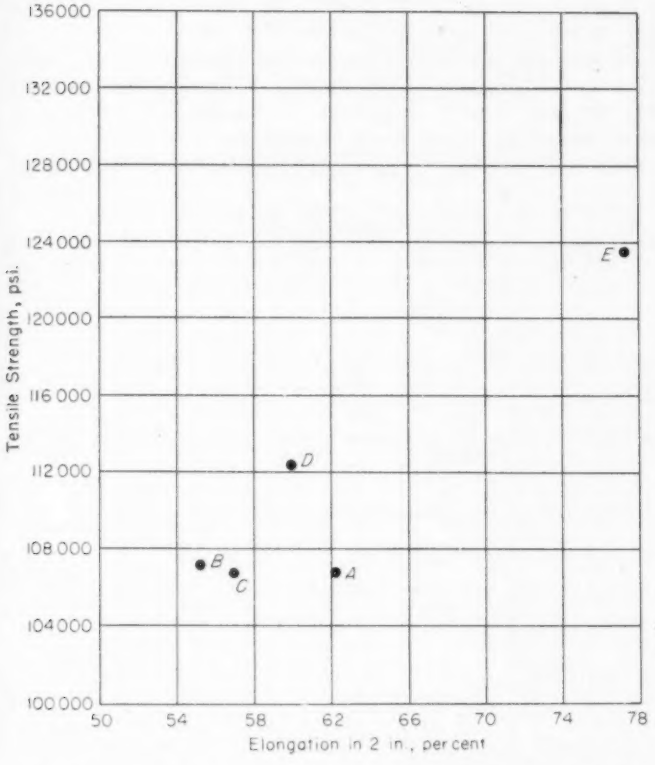

Fig. 1.—1942 Round-Robin Tension Tests Showing Variation in Tensile Strength and Elongation of Type 301 Annealed Stainless Steel Sheets for Five Cooperating Laboratories.

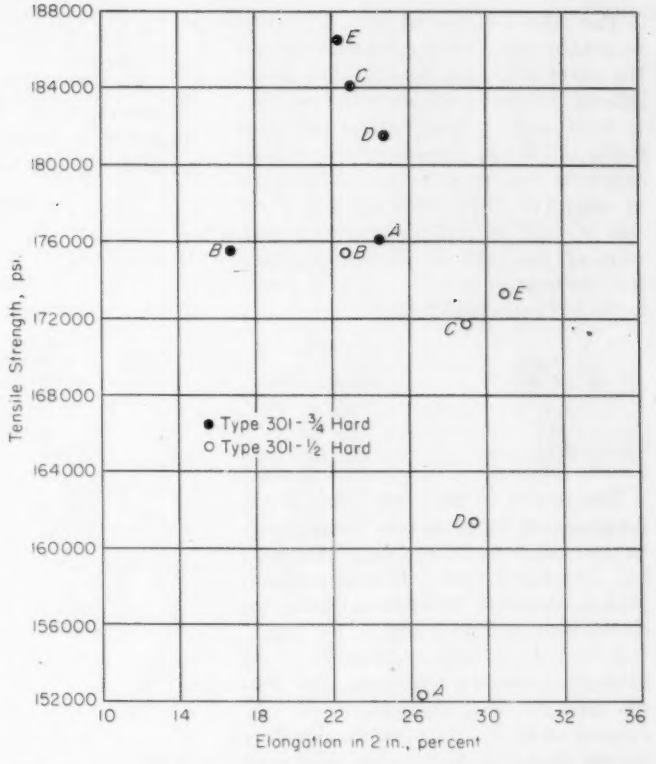

Fig. 2.—1942 Round-Robin Tension Tests Showing Variation in Tensile Strength and Elongation of Type 301—½ Hard and ¾ Hard Stainless Steel Sheets for Five Cooperating Laboratories.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Research Laboratories, Armco Steel Corp., Middletown, Ohio.

[2] Standard Methods of Tension Testing of Metallic Materials (E 8-46), 1946 Book of A.S.T.M. Standards, Part I-A, p. 698.

TABLE I.—1942 ROUND-ROBIN TENSION TESTS ON FLAT STAINLESS STEEL MATERIALS.

Type	A.S.T.M. Designation	Thickness, in.
301—annealed	A 167 Grade 1	0.090
301—½ hard	A 177—½ hard	0.009
301—¾ Hard	A 177—¾ hard	0.010
304	A 167 Grade 3	0.056
321	A 167 Grade 5	0.041
347	A 167 Grade 6	0.050
430	A 176 Grade 4	0.035

AVERAGE RESULTS FOR TYPE 301 ANNEALED

(Data for other grades not tabulated—see Figs. 1 to 3)

Laboratory	Crosshead Speed,[a] in. per min.	Tensile Strength, psi.	Elongation, in in 2 in., per cent
A	0.50	106,800	62.2
B	. .	107,200	55.3
C	0.48	106,800	57.0
D	0.45	112,400	60.0
E	0.04[b]	123,500	77.3

[a] Testing speeds for the other grades were comparable at each laboratory.
[b] Rate of strain in in. per in. per min.

The subcommittee undertook in 1943 to obtain more specific information on the effect of testing speed. The grade selected for this program was type 301, ¼ hard and ½ hard (0.024 in. and 0.031 in. thick, respectively). Triplicate tests were made by each laboratory at each of the following crosshead speeds. (It is not definitely known whether the several laboratories used free running or actual crosshead speed in the 1942 and 1943 tests.)

To Yield, in. per min.	Yield to Fracture, in. per min.
0.02	0.02
0.05	0.05
0.05	0.20
0.05	0.50

The results of the 1943 round-robin program are tabulated in an appendix to the annual report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys,[3] and are shown here in Figs. 4 and 5.

As in the previous program, low rates of strain produced relatively high tensile strength and elongation. It was evident that if the very low testing speeds could be eliminated, much of the difficulty in testing the speed-sensitive grades would be resolved. Consequently, it was recommended that the lower limit be set at ⅛ in. per in. of gage length per min. crosshead speed. As a practical upper limit ½ in. per in. of gage length per min. was recommended. These speed limits are now used in the stainless steel specifications A 167 and A 177.[4]

In the testing of thin flat tension specimens the smoothness of the machined edges in the gage length section was reported to have an important influence on the tensile strength and elongation values. In tests on type 301 made by one of the cooperating laboratories the average results for standard milled specimens were 148,900 psi. tensile strength and 26.8 per cent elongation. Duplicate specimens with hand-stoned edges gave average values of 159,700 psi. and 40.9 per cent.

A round-robin program to provide data on this subject was initiated in 1944 with the following laboratories participating:

The American Rolling Mill Co., Middletown, Ohio,
Carnegie-Illinois Steel Corp., Chicago, Ill.,
The International Nickel Co., Bayonne, N. J.,
Tinius Olsen Testing Machine Co., Philadelphia, Pa.,
Union Carbide and Carbon Research Labs., Niagara Falls, N. Y., and
Vanadium Corporation of America, Bridgeville, Pa.

In the 1942 and 1943 programs all materials were machined as uniformly as possible by one laboratory, milling the gage-length section in a direction parallel to the axis of the specimen. In the 1944 program one laboratory machined specimens by three different methods, and in addition each cooperating laboratory machined a group of specimens according to its standard practice and returned it to be tested by the first-mentioned laboratory. The material was all taken from one 0.0315-in. thick sheet of type 301 ¼ hard (A.S.T.M. Specification A 177—¼ hard) and machined as follows:

(*a*) Straight milled using one rough cut and a finishing cut of about 0.005 in. on the parallel-gage section.

(*b*) Cross milled using a three-part form cutter for milling the grip ends and the gage length simultaneously. The center portion of the gage length was reduced or tapered 0.003 in. in width. Three cuts were used, the finishing cut being about 0.005 in.

(*c*) Same as (*a*), except edges polished by hand using 180 grit and No. 1 emery papers.

(*d*) Sheared blanks supplied to each laboratory to be machined according to its standard practice and returned for testing to the laboratory which supplied the material.

Based on the results obtained in the 1943 program, a speed of testing of 0.2 in. per in. of gage length per min. was selected for all tests.

When the results of the 1944 program became available (Fig. 6), it was immediately apparent that the variations in tensile properties due to differences in specimen preparation were insignificant compared to the variations between laboratories. Although speed of testing was believed to be controlled at a fixed rate within the limits given in

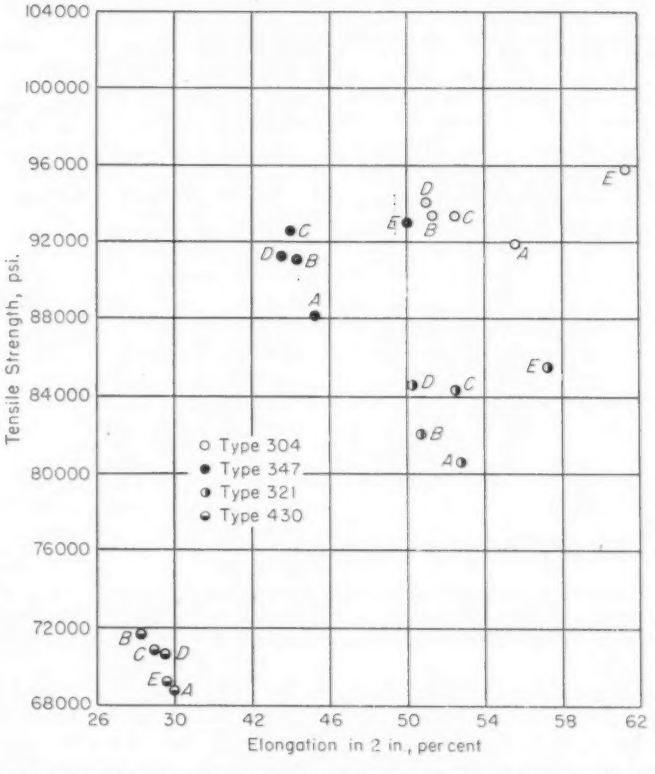

Fig. 3.—1942 Round-Robin Tension Tests Showing Variation in Tensile Strength and Elongation of Types 304, 321, 347, and 430 Stainless Steel Sheets for Five Cooperating Laboratories.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 44, p. 133 (1944).
[4] Specifications for Corrosion-Resisting Chromium-Nickel Steel Plate, Sheet and Strip (A 167-44), and Specifications for High-Strength Corrosion-Resisting Chromium Nickel Steel Plate and Strip (A 177-44), 1946 Book of A.S.T.M. Standards, Part I-A, pp. 448 and 455, respectively.

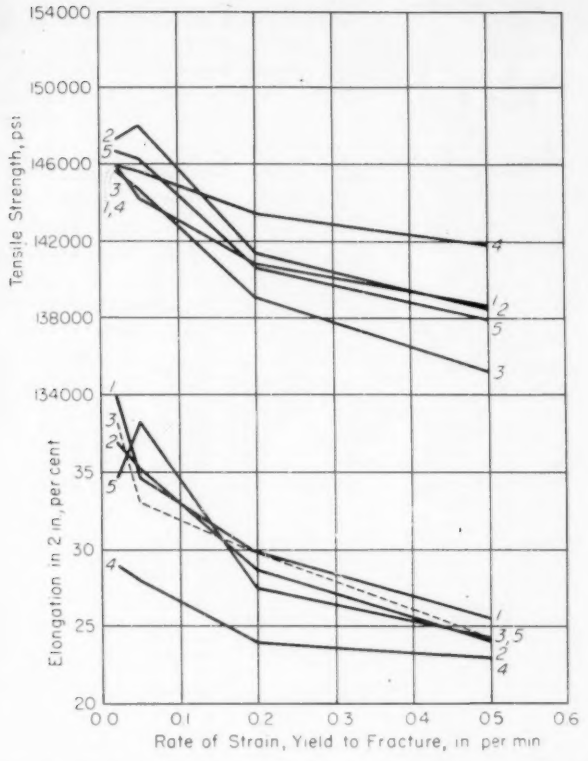

Fig. 4.—1943 Round-Robin Tension Tests Showing Effect of Rate of Strain on Tensile Strength and Elongation of Type 301—¼ Hard Stainless Steel Sheets Tested at Five Cooperating Laboratories.

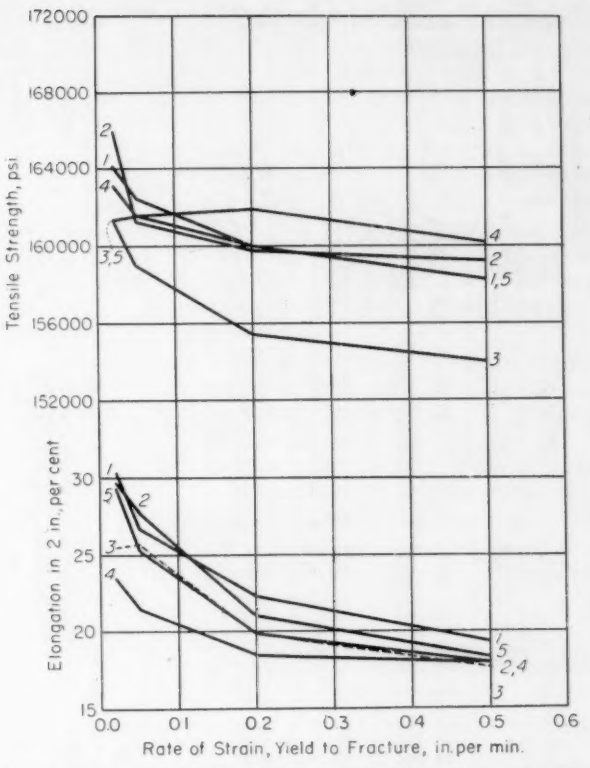

Fig. 5.—1943 Round-Robin Tension Tests Showing Effect of Rate of Strain on Tensile Strength and Elongation of Type 301—½ Hard Stainless Steel Sheets Tested at Five Cooperating Laboratories.

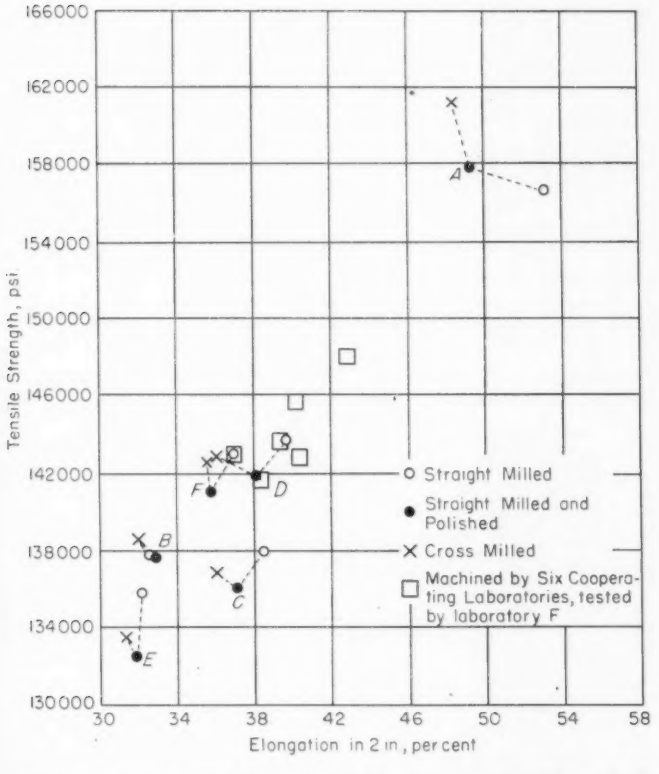
Tensile Strength, psi
Elongation in 2 in., per cent
Straight Milled
Straight Milled and Polished
Cross Milled
Machined by Six Cooperating Laboratories, tested by laboratory F

Fig. 6.—1944 Round-Robin Tension Tests Showing Variation in Tensile Strength and Elongation of Type 301—¼ Hard Machined by Different Practices and Tested by Six Cooperating Laboratories.

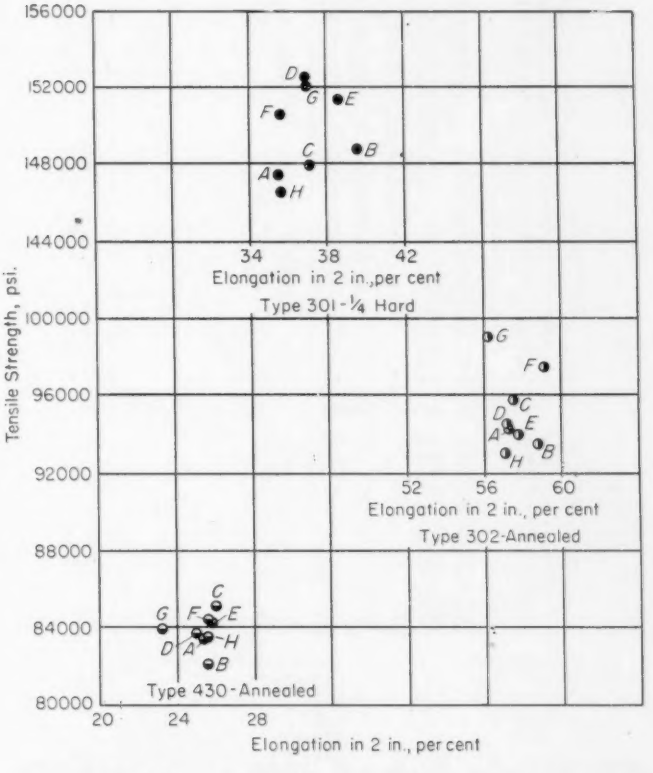
Tensile Strength, psi.
Elongation in 2 in., per cent
Type 301-¼ Hard
Elongation in 2 in., per cent
Type 302-Annealed
Type 430-Annealed
Elongation in 2 in., per cent

Fig. 7.—1948 Round-Robin Tension Tests Showing Variation in Tensile Strength and Elongation of Types 301—¼ Hard, 302 Annealed, and 430 Annealed Stainless Steel Sheets for Eight Cooperating Laboratories Used Controlled Time of Test from Yield Strength to Fracture.

TABLE II.—1948 TESTS—TYPE 302—ANNEALED (0.0325-IN. THICKNESS).

Laboratory	Test No.	Tensile Strength, psi.	Elongation, in 2 in., per cent	Test Time, Yield to Fracture, min.: sec.
A	A 21	94 000	58.0	4:00
	A 22	94 000	58.5	3:45
	A 23	94 000	56.5	2:45
	A 24	94 000	56.5	2:55
	A 25	95 000	57.0	2:55
		94 200	57.3	3:16
B	A 113	95 390	60.0	3:02
	A 114	93 940	56.0	2:57
	A 115	91 300	57.0	3:01
	A 116	92 420	57.5	2:57
	A 117	93 940	58.5	2:55
	A 118	93 320	60.0	3:07
	A 119	93 770	61.0	3:00
	A 120	93 050	60.5	3:02
		93 390	58.8	3:00
C	A 72	94 200[a]	57.5[a]	..
	A 73	96 600[a]	58.5[a]	..
	A 74	96 300[a]	...	...
	A 76	95 700	57.0	2:41
	A 77	95 500	57.0	2:37
	A 78	95 600	58.0	2:35
	A 79	95 000	57.0	2:54
	A 80	96 700	58.5	2:49
		95 700	57.5	2:43
D	A 1	93 600[a]	56.5[a]	2:43[a]
	A 2	94 500	57.0	3:02
	A 3	94 500	57.0	3:01
	A 4	94 500	57.5	2:56
	A 5	94 400	57.0	2:54
	A 6	94 400	57.0	2:52
	A 7	94 500	57.5	3.00
	A 8	94 400	57.5	2.59
	A 9	94 400	57.5	2:56
	A 10	94 400	57.0	2:51
		94 500	57.2	2:58
E	A 91	91 900[a]	57.0[a]	2:45[a]
	A 92	94 400[a]	57.0[a]	2:38[a]
	A 93	94 800	60.0	2:48
	A 94	92 300	56.5	2:38
	A 95	94 400	56.5	2:37
	A 96	93 900	58.0	3:08
	A 97	94 100	58.0	3:04
		93 900	57.8	2:51
F	A 81	97 180[a]	60.0[a]	2:53[a]
	A 82	96 550[a]	57.5[a]	2:56[a]
	A 83	98 120	61.0	3:04
	A 84	96 250	58.5	2:56
	A 85	98 440	59.5	2:57
	A 86	96 880	58.0	2:48
	A 87	97 500	58.5	2:51
		97 440	59.1	2:55
G	A 54	98 600	55.5	2:56
	A 55	99 400	57.5	3:00
	A 56	99 100	55.5	2:35
	A 57	98 800	55.5	3:05
	A 60	99 100	57.0	2:52
		99 000	56.2	2:57
H	A 41	93 700[a]	59.0[a]	4:55[a]
	A 42	92 500[a]	58.0[a]	3:27[a]
	A 43	91 700	57.0	2:48
	A 44	93 250	57.0	2:50
	A 45	93 250	58.0	2:50
	A 46	93 200	57.0	2:47
	A 47	93 500	57.0	2:47
	A 48	93 100	58.0	2:50
	A 49	92 750	57.0	2:49
	A 50	92 900	56.0	2:45
		92 960	57.1	2:48

[a] Trial test to establish test time—not included in average.

TABLE III.—1948 TESTS—TYPE 301—¼ HARD (0.0305-IN. THICKNESS)

Laboratory	Test No.	Tensile Strength, psi.	Elongation, in 2 in., per cent	Test Time, Yield to Fracture, min.: sec.
A	B 21	148 000	35.0	1:30
	B 22	148 000	35.5	1:50
	B 23	147 000	35.5	1:50
	B 24	145 000	35.5	1:45
	B 25	148 000	36.0	1:55
		147 400	35.5	1:48
B	B 113	147 890	39.0	2:08
	B 114	150 500	41.5	1:58
	B 115	146 580	37.5	2:09
	B 116	150 500	42.0	1:59
	B 117	147 280	37.0	2:09
	B 118	148 730	40.0	1:52
	B 119	148 580	40.0	1:50
	B 120	149 390	40.0	1:47
		148 700	39.6	1:59
C	B 72	152 400[a]	37.5[a]	..
	B 73	150 700[a]	37.5[a]	..
	B 74	148 000[a]	38.0[a]	..
	B 76	148 000	35.0	1:32
	B 77	147 700	36.5	1:42
	B 78	147 200	37.5	1:52
	B 79	148 300	37.0	1:51
	B 80	148 500	39.5	2:04
		147 900	37.1	1:48
D	B 1	154 800[a]	37.5[a]	2:00[a]
	B 2	153 000	37.0	1:51
	B 3	149 400	34.0	1:40
	B 4	152 800	36.5	2:02
	B 5	152 800	36.5	2:05
	B 6	151 400	36.5	1:55
	B 7	154 700	38.0	2:05
	B 8	151 400	36.0	1:52
	B 9	155 000	39.0	2:11
	B 10	151 600	38.5	2:04
		152 500	36.9	1:58
E	B 91	146 800[a]	35.0[a]	1:35[a]
	B 92	146 800[a]	40.0[a]	1:42[a]
	B 93	145 300	36.0	1:45
	B 94	152 400	38.0	2:21
	B 95	154 800	42.0	2:18
	B 96	150 800	37.0	1:59
	B 97	153 000	40.0	2:10
		151 300	38.6	2:07
F	B 81	154 100[a]	39.5[a]	2:37[a]
	B 82	149 650[a]	35.0[a]	1:37[a]
	B 83	150 350	35.0	1:32
	B 84	151 650	37.5	1:35
	B 85	152 350	37.5	1:45
	B 86	148 350	35.0	1:31
	B 87	149 650	33.0	1:32
		150 500	35.6	1:35
G	B 54	154 200	37.5	1:45
	B 55	151 600	37.5	1:43
	B 56	150 600	35.5	1:38
	B 57	152 900	37.0	1:42
	B 59	151 100	37.5	1:39
		152 000	37.0	1:41
H	B 41	146 800	35.0	1:40
	B 42	148 200	37.0	1:40
	B 43	148 900	37.0	1:42
	B 44	146 550	36.0	1:44
	B 45	144 300	35.0	1:36
	B 46	147 250	35.0	1:36
	B 47	145 900	35.0	1:43
	B 48	145 300	35.0	1:40
	B 49	144 600	36.0	1:42
	B 50	147 600	35.0	1:41
		146 500	35.6	1:40

[a] Trial test to establish test time—not included in average.

TABLE IV.—1948 TESTS—TYPE 430—ANNEALED (0.029-IN. THICKNESS).

Laboratory	Test No.	Tensile Strength, psi.	Elongation, in 2 in., per cent	Test Time, Yield to Fracture, min.: sec.
A	C 21	84 000	25.0	1:15
	C 22	84 000	25.5	1:20
	C 23	83 000	25.5	1:15
	C 24	83 000	25.0	1:10
	C 25	83 000	25.0	1:10
		83 400	25.4	1:14
B	C 113	83 930	25.5	1:13
	C 114	83 100	26.0	1:14
	C 115	82 590	25.0	1:11
	C 116	82 420	26.0	1:13
	C 117	82 420	26.0	1:14
	C 118	81 380	26.0	1:03
	C 119	81 380	25.0	1:03
	C 120	80 690	25.5	1:01
		82 110	25.6	1:13
C	C 71	85 600[a]	25.5[a]	..
	C 72	85 300[a]	25.5[a]	..
	C 73	84 500[a]	25.5[a]	..
	C 76	84 600	26.0	1:15
	C 77	84 600	26.0	1:16
	C 78	85 000	25.5	1:12
	C 79	85 300	26.0	1:12
	C 80	86 000	26.5	1:12
		85 100	26.0	1:16
D	C 1	82 000[a]	25.0[a]	1:58[a]
	C 2	82 600	25.0	1:07
	C 3	83 200	24.0	1:15
	C 4	83 400	25.0	1:15
	C 5	83 800	25.5	1:15
	C 6	83 800	25.0	1:14
	C 7	84 000	25.5	1:12
	C 8	84 100	25.0	1:18
	C 9	84 300	25.0	1:18
	C 10	83 800	25.5	1:12
		83 670	25.0	1:14
E	C 91	82 800[a]	25.0[a]	1:05[a]
	C 92	83 200[a]	25.0[a]	1:10[a]
	C 93	83 900	26.0	1:19
	C 94	84 600	26.5	1:14
	C 95	84 600	26.0	1:12
	C 96	83 600	25.0	1:06
	C 97	84 300	25.5	1:08
		84 200	25.8	1:12
F	C 81	84 720[a]	25.5[a]	1:24[a]
	C 82	84 450[a]	26.5[a]	1:27[a]
	C 83	85 080	26.0	1:23
	C 84	84 480	25.5	1:19
	C 85	84 140	25.0	1:24
	C 86	84 140	26.0	1:24
	C 87	84 140	25.5	1:22
		84 400	25.6	1:22
G	C 56	84 000	24.0	1:12
	C 57	84 100	23.5	1:14
	C 58	83 700	22.5	1:13
	C 59	83 800	23.5	1:13
	C 60	83 700	22.5	1:14
		83 900	23.2	1:13
H	C 41	84 000	26.0	1:10
	C 42	85 350	26.0	1:14
	C 43	84 000	26.0	1:19
	C 44	83 600	26.0	1:22
	C 45	83 600	26.0	1:25
	C 46	83 300	26.0	1:16
	C 47	82 950	25.0	1:10
	C 48	83 100	25.0	1:16
	C 49	82 600	25.0	1:13
	C 50	82 250	25.0	1:15
		83 480	25.6	1:16

[a] Trial test to establish test time—not included in average.

specifications A 177, it was demonstrated by additional tests that most of the variations between laboratories shown in Fig. 6 could be accounted for by changes in testing speed.

The variations due to machining practice indicate that cross milling results in slightly lower elongation than straight milling. The transverse-machining marks and the reduction in width at the center of the gage length produced by the cross-milling practice probably account for this difference. The edge-polished longitudinal milled specimens gave elongations intermediate

between the cross-milled and longitudinal-milled specimens. This was not in accord with the preliminary tests which prompted this program. On the other hand, the tests made in one laboratory on specimens machined in the various laboratories showed a range of elongations from 37 per cent to 43 per cent (Fig. 6).

Although the 1944 program again cast doubt on the effectiveness of the established controls on speed of testing, no further work was done on this problem until 1948. The cooperating laboratories in the 1948 program were:

Allegheny Ludlum Steel Corp., Brackenridge, Pa.,
Armco Steel Corp., Middletown, Ohio,
Carnegie-Illinois Steel Corp., Chicago, Ill.,
Eastern Stainless Corp., Baltimore, Md.,
General Electric Corp., Schenectady, N. Y.,
The International Nickel Co., Bayonne, N. J.,
Republic Steel Corp., Cleveland, Ohio, and
Union Carbide and Carbon Research Labs., Niagara Falls, N. Y.

The materials selected for the 1948 round-robin were:

(*a*) Type 302 annealed—A.S.T.M. A 167 Grade 2, 0.0325 in. thick.

(*b*) Type 301 ¼ hard—A.S.T.M. A 177—¼ hard, 0.0305 in. thick.

(*c*) Type 430 annealed—A.S.T.M. A 176 Grade 4, 0.029 in. thick.

Specimens of each type were taken from a single sheet and machined by one laboratory using longitudinal milling practice without special edge preparation. The following instructions were given on speed of testing:

"The speed of testing for the determination of tensile strength and elongation is to be based on a time of testing between the yield strength and fracture of 3 min. if the elongation is approximately 60 per cent and adjusted to this proportion for other values of elongation."

Elongation, per cent	Testing Time, Yield Strength to Fracture, min.
60	3
50	2.5
40	2
30	1.5
20	1
10	0.5

Two specimens were supplied for adjustment of the testing machine speed. Five specimens were then pulled at a uniform rate with time from yield strength to fracture adjusted approximately to the elongation. In some cases three additional tests were made at this setting on specimens supplied primarily for yield strength determination.[5] All data are included in Tables II, III, and IV. The average results are plotted in Fig. 7 to the same scale as used for the preceding figures. As a means of comparing the results of the 1944 and 1948 programs the total range of test results for each program is shown in Table V.

The improvement in results obtained by the time to fracture procedure over the rate of strain procedure is believed to be due to the greater ease of controlling the former. Unless a low magnification extensometer is used on the specimen to check strain rate during the test, it is necessary to rely on crosshead speed, with a factor to correct for

[5] The yield-strength data obtained in the course of these round-robin programs will be reported separately.

TABLE V.—COMPARISON OF RESULTS OF 1944 AND 1948 PROGRAMS.

Type	1944[a] (Rate of Strain)	1948 (Time from Yield to Fracture)
301—¼ hard		
Tensile strength:		
Range, psi.	20 800	6 000
Range, per cent of avg.	14.6	4.0
Elongation:		
Range, per cent in 2 in.	20.9	4.1
Range, per cent of avg.	53.7	11.1
302—annealed		
Tensile strength:		
Range, psi.	....	6 040
Range, per cent of avg.	....	6.3
Elongation:		
Range, per cent in 2 in.	....	2.9
Range, per cent of avg.	....	5.0
430—annealed		
Tensile strength:		
Range, psi.	....	3 000
Range, per cent of avg.	....	3.6
Elongation:		
Range, per cent in 2 in.	....	2.8
Range, per cent of avg.	....	11.1

[a] Longitudinal milled specimens only.

TABLE VI.—COMPARISON OF AIR COOLING AND DAMP CLOTH PROCEDURES—SAME MATERIALS AS USED IN 1948 TESTS.

Test No.	Type	Tensile Strength, psi.	Elongation in 2 in., per cent	Head Speed, in per min.
DAMP CLOTH PROCEDURE				
A 101	302—annealed	105 850	59.0	0.6
A 102	302—annealed	107 720	55.0	0.6
B 101	301—¼ hard	175 410	40.0	0.6
B 102	301—¼ hard	174 950	40.0	0.6
C 101	430—annealed	85 010	25.0	0.6
C 102	430—annealed	86 060	30.5	0.6
A 103	302—annealed	108 260	62.0	0.02
A 104	302—annealed	107 950	65.0	0.02
B 103	301—¼ hard	176 680	38.5	0.02
B 104	301—¼ hard	179 600	38.0	0.02
C 103	430—annealed	83 270	24.5	0.02
C 104	430—annealed	82 870	24.5	0.02
AIR-COOLING PROCEDURE				
A 109	302—annealed	101 540	80.0	0.02
A 110	302—annealed	99 690	78.0	0.02
B 109	301—¼ hard	165 230	44.0	0.02
B 110	301—¼ hard	65 880	49.0	0.02
C 109	430—annealed	82 240	29.0	0.02
C 110	430—annealed	81 380	27.5	0.02

TABLE VII.—COMPARISON OF AIR COOLING AND DAMP CLOTH PROCEDURES AT HIGH TESTING SPEED—SAME MATERIALS AS USED IN 1948 TESTS.

Test No.	Type	Tensile Strength, psi.	Elongation in 2 in., per cent	Head Speed, in. per min.
DAMP CLOTH PROCEDURE				
A 107	302—annealed	101 660	56.0	1.0
A 108	302—annealed	104 610	58.0	1.0
A 107	301—¼ hard	165 880	44.0	1.0
A 108	301—¼ hard	171 120	44.0	1.0
C 107	430—annealed	86 210	24.0	1.0
C 108	430—annealed	85 860	26.0	1.0
AIR-COOLING PROCEDURE				
A 105	302—annealed	83 480	58.0	1.0
A 106	302—annealed	91 610	58.0	1.0
B 105	301—¼ hard	145 200	34.5	1.0
B 106	301—¼ hard	145 860	35.0	1.0
C 105	430—annealed	81 900	25.0	1.0
C 106	430—annealed	82 070	25.0	1.0

CHECK ANALYSIS OF THE TYPE 301—¼ HARD MATERIAL

Carbon, per cent	0.095
Chromium, per cent	17.24
Nickel, per cent	7.22

lost motion in the grips and in stretching the specimen in the shoulder and fillet areas between the grips and the gage-length points. The latter motion is quite considerable in the testing of thin, flat austenitic stainless steels. The effective stretch in the gage length may be as low as 40 per cent of the crosshead movement. The question of difference between free-running and loaded crosshead speed also enters into the problem. In cases where the operator uses nominal crosshead speed without any correction it is certain that the actual rate of strain in the gage length is much lower than the apparent rate, and high strength and elongation results are likely. With a low magnification extensometer on the gage length section, it is possible to operate at a specified rate of strain, and good checks should be obtained between laboratories. The method of timing the test appears to accomplish the same purpose.

In the 1948 program, an extra set of specimens was sent to R. A. Lincoln of Allegheny Ludlum Steel Corp. for a demonstration of the effect of temperature on the tensile properties of stainless steels, using the "damp cloth" method of cooling the specimens during tests. See Tables VI and VII for results.

Note in Table VI that type 301—$\frac{1}{4}$ hard developed approximately 165,000 psi. tensile strength and 45 per cent elongation when pulled at the very low rate of 0.02 in. per min., with no precautions taken to cool the specimens. When pulled at this same rate using the damp cloth for cooling an even higher strength but lower elongation was obtained. Comparing the tests at the two head speeds in the first section of Table VI there is little difference to be noted, indicating that the damp cloth was effective in keeping the temperature from rising in the faster tests. In Table VII a comparison is made at a high head speed, with and without water cooling. The relatively low values of approximately 145,000 psi. tensile strength and 35 per cent elongation obtained for type 301—$\frac{1}{4}$ hard in the air-cooled tests are closest to the values obtained by the eight laboratories in the time-controlled tests (Fig. 7). The other procedures in Tables VI and VII involving very slow testing speeds, water cooling, or both, all tend to keep the temperature down and give high test values. Note that the ferritic steel, type 430, was little affected by any of these procedures.

From these and other data on temperature effect, it is clear that the speed sensitivity of the austenitic stainless steels is a reflection of their sensitivity to the effects of cold working at various temperatures in the vicinity of room temperature. While this suggests temperature control in the tension test, practical considerations favor control of testing speed.

Subcommittee V of A-10 is publishing the above data at this time because of interest expressed by other groups in the method of controlling speed of testing by time of test.

Discussion of Paper on Approximate Statistical Method for Fatigue Data[1]

MR. BENJAMIN EPSTEIN[2] (*by letter*).—I should like to point out that in seeking a sound statistical procedure for statistical data, one may find it of great use to study methods applied in psychophysical testing, in biological assay, and in the testing of explosives. The data arising from all problems of this type are known technically as "Sensitivity Data."

In the field encompassed by "Sensitivity Data" one calls the "stimulus" that condition to which the sample under test is subjected. By a "critical stimulus" one means the stimulus at which a given object just responds (or just fails); that is, for a stimulus of less intensity than the critical stimulus, the object will not respond (will not fail), and for a stimulus of greater intensity than the critical stimulus, the object will respond (will fail). For example:

Objects Tested	Type of Stimulus	Critical Stimulus
Human ear..	Sound	Strength of sound which ear can just hear
Organisms ..	Dosage of drug	Amount just necessary to kill
Primer caps.	Blow	Energy of blow just necessary to explode
Metal specimens.....	Stress repeated some fixed number of times (for example, 10,000,000)	Stress just necessary to lead to fatigue failure

In all these problems the testing technique involves testing specimens at a series of intensity levels ranging from that level at which there are practically no failures to that level at which almost all specimens will fail. What is meant by "practically no failures" and "almost all specimens" can be made more precise.

As references one can mention the following:

(1) C. Spearman, "The Method of Right and Wrong Cases (constant stimuli) without Gauss' Formula," British *Journal of Psychology*, Vol. 2, pp. 227–242 (1908).

(2) C. I. Bliss, "The Calculation of the Dosage Mortality Curve," *Annals of Applied Biology*, Vol. 22, pp. 134–167 (1935).

(3) B. Epstein and C. W. Churchman, "On the Statistics of Sensitivity Data," *Anals of Mathematical Statistics*, Vol. 15, pp. 90–96 (1944).

(4) C. W. Churchman and B. Epstein, "Tests of Increased Severity," *Journal*, Am. Statistical Assn., Vol. 41, pp. 567–590 (1946).

(5) "Statistical Analysis for a New Procedure in Sensitivity Experiments," Report No. 101.1 R of the Applied Mathematics Panel, National Defense Research Council, July, 1944. A report by the Statistical Research Group, Princeton University.

(6) T. W. Anderson, P. J. McCarthy, and J. W. Tukey, " 'Staircase' Methods of Sensitivity Testing," *Navord Report 65-46*, March, 1946.

It is our purpose in this discussion to bring to the attention of workers studying the fatigue of materials the existence of techniques in other fields of science which are relevant to the problem at hand. The whole subject, however, merits a much fuller discussion, and therefore it is suggested that the ideas sketched here be made one of the topics of discussion at a future symposium.

MR. HARRY PRESS[3] (*by letter*).—The suggestion for the inclusion of measures of average values and standard deviations for nominal stress seems a good beginning point for statistical analysis. Additional investigation may indicate the desirability of including additional statistical parameters. The two methods, both the computational and graphical, described in the paper appear adequate for obtaining estimates of the mean and standard deviation of the defined variable S'. The graphical method, though simple, suffers somewhat from the added assumption of the normality of the distribution which may be open to some question. An additional refinement might be suggested for the computational method. In the equation for the standard deviation, the term n should be replaced by $n-1$ when used with small samples.

[1] R. E. Peterson, "Approximate Statistical Method for Fatigue Data," ASTM BULLETIN, No. 156, January, 1949, p. 50 (TP12).
[2] Wayne University, Detroit, Mich.
[3] Hampton, Va.

Influence of Type of Machine, Range of Speed, and Specimen Shape on Fatigue Test Data

By P. K. Roos,[1] D. C. Lemmon,[1] and J. T. Ransom[2]

SYNOPSIS

Fatigue tests were made on flat and round specimens of an S.A.E. 4340 steel in pure reversed plane bending at 1800 rpm. on a Sonntag universal fatigue testing machine; and on round specimens acting as rotating beams on R. R. Moore fatigue machines at 1800 rpm. and 10,000 rpm. The data show that a higher endurance limit is obtained in pure reversed plane bending tests than in rotating-beam tests; in round specimens subjected to pure reversed plane bending than in flat specimens similarly tested; and in rotating-beam tests performed at 10,000 rpm. than in those performed at 1800 rpm.

SCOPE OF THE INVESTIGATION

This investigation was undertaken to compare fatigue test data obtained from R. R. Moore fatigue testing machines using rotating-beam specimens with data obtained from a Sonntag universal fatigue testing machine using specimens of different shapes tested in pure reversed plane bending.

Since R. R. Moore machines are commonly run at speeds of 10,000 rpm., and since the Sonntag machine operates at a speed of 1800 rpm., a plan was adopted to obtain data for S–N curves up to 10^7 cycles on the same material under these four conditions:

1. At 10,000 rpm. using R. R. Moore machines and R. R. Moore specimens.
2. At 1800 rpm. using an R. R. Moore machine and R. R. Moore specimens.
3. At 1800 rpm. using a Sonntag machine and R. R. Moore specimens modified to fit the Sonntag gripping fixtures.
4. At 1800 rpm. using a Sonntag machine and flat specimens with certain dimensions related to the R. R. Moore specimens.

MATERIAL AND SPECIMENS

The material used in the tests was taken from a 40-mm. gun barrel forging of S.A.E. 4340 steel. The heat treatment consisted of water quenching and drawing to a static yield strength in tension of 107,000 psi. and an ultimate static tensile strength of 127,000 psi.

The specimens were all taken from the same region in the forging and all had the same orientation in that the longitudinal axes of the specimen were parallel to the longitudinal axis of the forging. Figure 1 shows the three types of specimens used. It will be noted that specimen A, the R. R. Moore specimen, is cut with a single $5\frac{1}{4}$-in. radius. Specimen B has the same reduced section as specimen A and differs only in the provisions made for holding the specimen. Specimen C, the flat specimen, has a thickness, 0.3 in., equal to the minimum diameter of the R. R. Moore specimens and a reduced section of the same length using the same radius of curvature as the R. R. Moore specimens. All specimens were carefully polished and after polishing were heated to 1000 F. for one hour in a special atmosphere to relieve any surface hardening due to polishing.

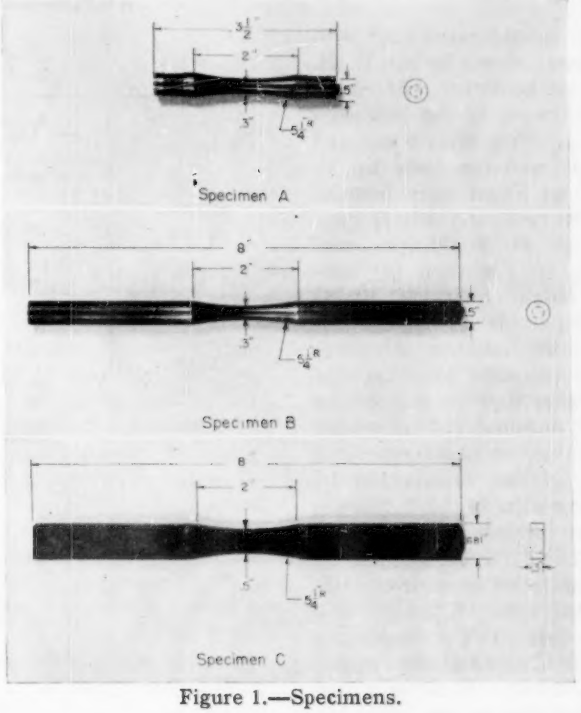

Figure 1.—Specimens.

THE TESTING MACHINES

A battery of six R. R. Moore machines was used to test specimens A as rotating beams at 10,000 rpm.; a single R. R. Moore machine, which could be run at different speeds, was used for some tests at 10,000 rpm. and all tests at 1800 rpm.; and a Sonntag machine tested specimens B and C at 1800 rpm. in completely reversed pure plane bending. In the testing of specimen C the flat sides were the top and bottom surfaces of the beam.

The Sonntag universal fatigue testing machine is a centrifugal force, inertia compensated machine described

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

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[2] Research Engineer, E. I. du Pont de Nemour and Company, Wilmington, Del.

[3] The boldface numbers in parentheses refer to the list of references appended to this paper.

in detail by Lazan (1).[3] Its application to various fatigue problems has been discussed by Sauer and Roos (2). The speed of the motor which drives the eccentric weight that causes the centrifugal force is 1800 rpm., and when this speed is referred to in connection with this machine it is used as a convenient way of saying that the specimen has undergone 1800 reversals or cycles of stress, since one revolution of the motor drives the specimen through one cycle of stress change.

Failure, in this investigation, is defined as such change in condition of the specimen as allows enough increased deflection to cause the automatic shut-off devices of the machines to operate.

Test Results

The data obtained from these tests on S.A.E. 4340 steel have been consolidated in Table I. These data plotted on a semi-log basis give the four average curves shown in Fig. 2. In descending order of endurance limit at 10^7 cycles, the data show:

(1) Specimen *B* (round) — 72,000 psi. (Sonntag machine, 1800 rpm.).
(2) Specimen *A* (round) — 67,000 psi. (R. R. Moore machine, 10,000 rpm.).
(3) Specimen *C* (flat) — 66,000 psi. (Sonntag machine, 1800 rpm.).
(4) Specimen *A* (round) — 64,000 psi. (R. R. Moore machine, 1800 rpm.).

The increase in endurance limit with increase in speed shown in the R. R. Moore machine conforms with other test results reported in the literature on this subject. This effect was noted by Krouse (3) who ran tests up to 30,000 rpm. and found more increase between 10,000 rpm. and 30,000 rpm. than for speeds of 10,000 rpm. and below. Oberg and Johnson (4) concluded that fatigue limits at 10,000 rpm. are comparable to results obtained at a lower number of cycles. Wishart, in a discussion following this same article, says that on one or two occasions he has found the endurance limit as determined at 10,000 rpm. and 3600 rpm. has varied as much as 10 per cent. The results in this investigation indicate an increase of 4.7 per cent in endurance limit for a change in R. R. Moore machine testing speed from 1800 rpm. to 10,000 rpm. Although this is not in agreement with the conclusions of the Research Committee on Fatigue of the A.S.T.M. (5) based on many more tests, these results are based on specimens of the same size and shape.

The *S–N* curve for the R. R. Moore machine rotating-beam tests at 1800 rpm. shows an endurance limit of 64,000 psi. When a specimen of the same

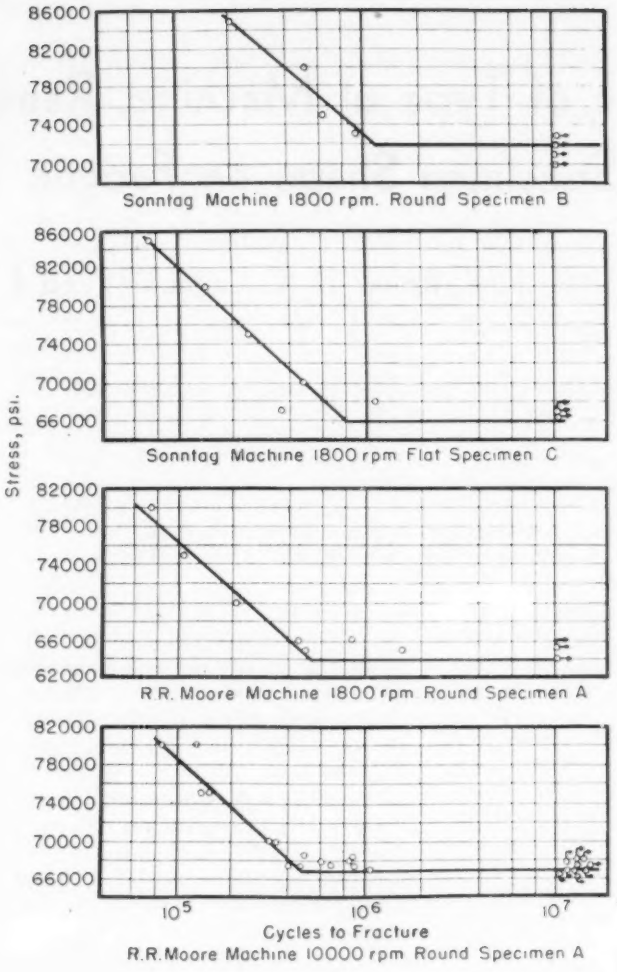

Fig. 2.— S-N Curves.

TABLE I.—FATIGUE DATA.[a]

Stress, psi.	Specimen *A* (Round), R. R. Moore Machine, cycles		Specimen *B* (Round), Sonntag Machine, 1800 rpm., cycles	Specimen *C* (Flat), Sonntag Machine, 1800 rpm., cycles
	10,000 rpm.	1800 rpm.		
85 000	....	....	204 800	72 500
80 000	83 000	79 000	507 800	131 500
	127 000			
75 000	132 000	106 000	614 400	241 800
	146 000			
73 200	....	....	935 400	....
73 000	....	....	10 232 500 U	....
72 000	....	....	10 323 000 U	....
71 000	....	....	10 167 900 U	....
70 000	303 000	201 000	10 339 700 U	463 900
	330 000			
68 500	468 000			
	854 000			
	598 000			1 140 600
	852 000			
68 000	12 992 000 U			
	13 458 000 U			
	388 000			
	441 000			
	624 000			
	884 000			
67 500	11 576 000 U			
	13 014 000 U			
	15 326 000 U			
	1 003 000			357 400
	10 518 000 U			10 203 200 U
67 000	11 486 000 U			10 334 500 U
	12 833 000 U			
	14 757 000 U			
	15 056 000 U			
66 500	10 000 000 U			10 197 800 U
	13 253 000 U			
66 000	....	431 000		
	....	803 000		
	....	471 000		
65 000	....	1 528 000		
	....	10 051 000 U		
	....	10 159 000 U		
64 000	....	10 314 000 U		

[a] U designates unbroken specimen.

cross-section is tested in a Sonntag machine in reversed bending at 1800 rpm. the endurance limit is 72,000 psi. Although nothing has been found in the literature with which this can be compared exactly, since the specimen shape does not vary, Fuller and Oberg (6) report the same kind of phenomenon, namely, that fatigue failure is related to the area or volume of material subjected to the greatest stress. In this case these two regions can be thought of, in the case of the reversed bending, as two points, and in the case of the rotating beam as the circumference of a circle whose diameter is the minimum diameter of the specimen. The more of a material exposed to the maximum stress condition the lower the endurance limit. In this case, the decrease amounts to 11.1 per cent. This is also in agreement with the Research Committee's results on rotating beam *versus* vibratory specimens, but in this case no adjustment for size effect is necessary.

The endurance limit of this S.A.E. 4340 steel when tested as a flat specimen in reversed bending at 1800 rpm. is 66,000 psi. This value is comparable to the values obtained from the rotating-beam R. R. Moore tests at both 1800 rpm. and 10,000 rpm. These, again, are the same kind of results reported by the Research Committee (5) and Fuller and Oberg (6), who showed that the more material in a specimen subjected to the maximum stress the more the endurance limit will be lowered. Peterson's and Dolan's discussions of the above article are particularly pertinent to the present data for both present evidence that the endurance limit is some function of the amount of material subjected to this maximum stress condition. In this connection it should be noted that the minimum circumference of the R. R. Moore specimens (region of highest stress) is approximately 0.9 in. and the minimum top plus bottom width of flat specimen *C* (region of highest stress) is approximately 0.8 in.

Conclusions

1. Increase in testing speed raises the endurance limit of S.A.E. 4340 steel.
2. Bending, accompanied by rotation, as in an axle, is a more severe fatigue condition than plane bending.
3. For plane bending, a round cross-section is more desirable for resistance to fatigue failure than a rectangular cross-section when both carry the same maximum fiber stress.

Acknowledgment:

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Discussion of the Paper on the Pressure Method for Air Content of Mortars[1]

Mr. B. Janer.[2]—The paper by Thomas G. Taylor in the December, 1948, issue of the ASTM Bulletin describing a small-scale air meter based on the method of Klein and Walker[3] for entrained air in concrete is interesting and informative. A study of the careful array of data in that report can lead only to complete agreement with Taylor's conclusions that "the small difference in air contents and degree of reproducibility does not warrant recommending it as a substitute for the present tentative gravimetric method for determining the air content of 1:4 mortar (ASTM Tentative Method C 185 - 47 T)" but that for concrete "the pressure method of test is much more reliable than the gravimetric method."

In his paper Taylor follows the lead of Menzel[4] in the calibration for determining the external pressure to be applied in order that the scale reading shall be numerically equal to the air content of the concrete sample as per cent by volume. Certainly, the method is correct; but some simplifications can be introduced without undue loss in accuracy. Since the pressure method is based on Boyle's law for gases and since the dimensions of the chosen piece of equipment are fixed, all the necessary constants can be computed from those dimensions. The discussion that follows illustrates the application of this principle to the air meter in use in this laboratory, a type as described by H. W. Russell.[5] With appropriate changes in the numerical values for the dimensions involved, the same method can be applied to air meters of other design details.

A constant volume, V in cubic inches, of a concrete sample contains v' cubic inches of air; expressed as a per cent by volume, $A = v' \times 100/V$. This is at atmospheric pressure in pounds per square inch, $P' = 0.491\ B$, where B is the barometric reading at the site in inches of mercury. The apparatus is locked and water added to the zero mark of the scale; the water head as measured from the flange rim of the bowl to the

[1] Thomas G. Taylor, "Determination of the Air Content of Mortars by the Pressure Method," ASTM Bulletin, No. 155, December, 1948, p. 44 (TP252).
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zero mark is W inches. The entrained air is now under pressure P'' psi., that is, atmospheric plus the equivalent of the water head and the equivalent of one-half the depth of the concrete sample in the bowl; the entrained air volume is now v'' cubic inches. Next, we apply the external pressure, G psi. as indicated on the gage, and the total pressure is now P''' and equal to P'' plus G diminished by the loss in head indicated by the drop in water level in the gage glass. This last can be expressed in terms of the scale reading if we measure the length in inches per scale division—constant k'. The volume of the entrained air shrinks to v''' and if we designate the shrinkage by $\Delta v''$, then $v''' = v'' - \Delta v''$. The term $\Delta v''$ can be evaluated in terms of scale reading, S, by calibrating the apparatus in terms of cubic inches equivalent to unit scale division—constant k''. Generally, then:

$$\frac{v''}{v'} = \frac{P'}{P''} \text{ and } v'' = \frac{P'}{P''}v'$$

$$\frac{v'''}{v'} = \frac{P'}{P'''}; \quad v''' = v'' - \Delta v''$$
$$= v'' - k''S$$

$$\frac{\frac{P'}{P''}v' - \Delta v''}{v'} = \frac{P'}{P'''} \text{ and}$$

$$P'(P''' - P'')\frac{VA}{100} = P''P'''(k''S) \ldots (1)$$

We consider now, by way of illustration, the application of this basic Eq. 1 to the air meter in use in this laboratory. All pressures, of course, must be converted into the same units, pounds per square inch.

$P' = 0.491\ B$, B being the barometer reading (in this New York area the mean is about 30 in.);

$h = 21.45$ in., over-all head in terms of inches of water for the full water column plus the equivalent of ½ the depth of the concrete sample in the bowl;

$P'' = P' + 0.0361\ h = 0.491\ B + 0.7744$;

$k' = 0.846$ in. per unit scale division, as measured;

$P''' = P'' + G - 0.0361 \times 0.846\ S$
$= 0.491\ B + 0.7744 + G - 0.0305\ S$, S being the scale reading under the applied pressure G;

$V = 350.8$ cu. in., by calibration, and

$k'' = 1.680$ cu. in. per unit scale division, by calibration.

Inserting the known numerical values where they fit in the basic Eq. 1, we have:

$$0.491\ B[(0.491\ B + 0.7744 + G - 0.0305\ S) - (0.491\ B + 0.7744)]\ 3.508\ A = (0.491\ B + 0.7744) \times (0.491\ B + 0.7744 + G - 0.0305\ S) \times 1.680\ S$$

Now impose the condition that A is equal to S numerically, combine terms and transpose:

$$0.8975\ BG - 1.2775\ B - 0.4050\ B^2 - 1.3009\ G - 1.0073 = (0.0274\ B - 0.0397)\ S \ldots\ldots (2)$$

This rigorous Eq. 2 can be solved to determine what applied pressure, G, shall be used when the barometer reads B in. in order that the scale reading shall be directly per cent entrained air in the sample. To avoid the necessity of dealing with so cumbersome an equation, certain approximations may be introduced without serious impairment of desired accuracy.

First: On the right-hand side consider the expression $(0.0274\ B - 0.0397)$.

At B equal to 33 in., the value of the expression would be 0.8645; at B equal to 30 in., 0.7823; and at B equal to 27 in., 0.7001

and 0.0397 as a per cent of $0.0274\ B$ would be:

At B equal to 33 in., 4.44 per cent; at B equal to 30 in., 4.89 per cent; and at B equal to 27 in., 5.43 per cent.

If this entire expression is replaced by the approximation $0.951 \times 0.0274\ B = 0.02606\ B$, the values would be:

At B equal to 33 in., 0.8599, an error of −0.5 per cent; at B equal to 30 in., 0.7817 an error of −0.1 per cent; and at B equal to 27 in., 0.7035 an error of +0.5 per cent.

Thus, for so wide and improbable a range of variation in values of B for any given locale, the error involved in this approximation is negligible and we may now write:

$$0.8975\ BG - 1.2775\ B - 0.4050\ B^2 - 1.3009\ G - 1.0073 = 0.02606\ BS$$

Divide through by $0.02606\ B$, remembering that $A = S$

$$S = A = 34.44\ G - 48.93 - 15.54\ B - 49.93\ G/B - 38.67/B$$

from which

$$G = \frac{15.54\ B - 38.67/B + 48.93 + A}{34.44 - 49.93/B} \ldots (3a)$$

We indulge ourselves in some further approximations with no serious error, as will be shown. In the expression $(15.54\ B - 38.67/B)$ the second term is so small with respect to the first that we may evaluate this fraction on the basis of $B = 30$ in. (or whatever may be the prevailing mean barometric pressure at the locale of operations), namely, 1.289. We may then write:

$$G = \frac{15.54\ B + 47.64}{34.44 - 49.93/B} + \frac{A}{34.44 - 49.93/B} \ldots (3b)$$

In this, further, the second fraction on the right must be quite small with respect to the first, and even for wide variations in the value of B it can affect G only slightly. Assume, then, as an approximation for this fraction, $B = 30$ in. and it reduces to $0.0305\ A$. As one step more, consider the denominator $(34.44 - 49.93/B)$. If the value of B equals 33, 30, and 27 in. successively the computed values of this expression are, respectively, 32.61, 32.78, and 32.94. This is a variation of only 0.33 or 1 per cent for all of the wide range assumed for B. Introduce this further approximation into Eq. 3*b* that for this expression $B = 30$ in. and we then get

$$G = 0.474\ B + 1.453\ B + 0.0305\ A \ldots (3c)$$

The pressure to be applied, G, is a function of the barometric reading *and* the air content of the sample.

As a test of the validity of the several approximations involved in arriving at this simplified equation, assume barometer readings of 33, 30, and 27 in. and compute for each the value of G by the rigorous Eq. 2 and by the approximate Eq. 3*c*, thus:

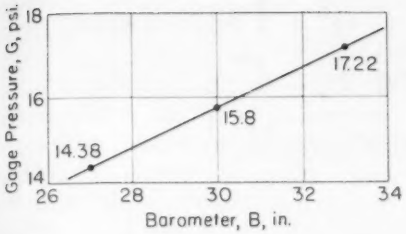
Barometer, in.	By Eq. 2	By Eq. 3*c*
33	$G = 17.10 + 0.0305\ A$	$G = 17.09 + 0.0305\ A$
30	$15.76 + 0.0305\ A$	$15.67 + 0.0305\ A$
27	$14.38 + 0.0305\ A$	$14.25 + 0.0305\ A$

The two series of computations agree within 0.1 psi. on the indicating gage and, it is submitted, that is close enough.

To carry this system to its logical conclusion, note that for the entire scale range (for our instrument 7.5) the computed values for the external pressure G can be affected only to the extent of 0 to 0.2 psi. Assume then, for general purposes, S at about the mid-point 4, and Eq. 3*c* reduces to

$$G = 0.474\ B + 1.575 \ldots\ldots (3)$$

This equation of a straight line makes possible a quick determination of the applied pressure to be used for any plausible range of variations of the baro-



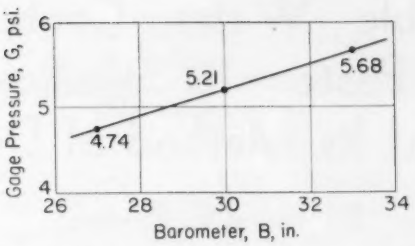
metric pressure at the site of operations. It is correct to within ±0.2 psi.

Is this range of error negligible? What is the effect of an error in the applied pressure, G, due to the faulty calibration of the pressure gage or by reason of faulty manipulation on the part of the operator? Assume that a sample of concrete containing 5 per cent of entrained air is under examination, that the barometer reading is 30 in., and that the indicated value for G is thus 15.8 psi. Insert the known constants in the basic Eq. 1 and compute the resulting scale reading S. We obtain 4.98, close enough to the expected 5.0. Now, if we assume an error of plus 3 psi. in the applied pressure and again use Eq. 1 to compute S, we obtain $S = 5.42$. An error of 1 psi. or 6.7 per cent in the gage pressure results in an error of 2.8 per cent in the air content determination. Thus, the approximations introduced in the above derivations, which involve errors of not more than 0.2 psi., can give rise to an error of not over 0.05 percentage points of air. This cannot be regarded as serious for such determinations.

At times it will occur that the air content is so high that the water level under the applied pressure falls below the limits of the scale. Such cases can be dealt with by using Eq. 1, imposing the condition that $A = 2\,S$ and proceeding as above an analogous equation can be developed. For our air meter with the dimensions shown, this is

$$G = 0.157 + 0.495 \quad \ldots\ldots\ldots (4)$$

Using this equation or the corresponding straight line graph we obtain quickly



the value of the applied pressure so that the air content in per cent is numerically equal to twice the scale reading. Here, however, errors in G are more serious. With the help of the basic Eq. 1 it can be shown that an error of 1 psi. or about 20 per cent in G can lead to an error of about 14 per cent in the value of A.

Thus any air meter can be calibrated once and for all by careful measurements of the dimensions of the apparatus, namely, the volume content of the bowl in cubic inches, the inside depth of the bowl, the height from the flange rim of the bowl to the zero mark of the scale, linear inches per unit on the scale, volume in cubic inches corresponding to the scale unit; and also with selection of the probable prevailing mean barometric pressure at the locale for purposes of the approximation steps indicated.

It is of some importance that the pressure gage furnished with such apparatus be of precision type and be calibrated over its entire range to an accuracy of ±0.2 psi., as checked against a mercury manometer.

Mr. Thomas G. Taylor (*author's closure*).—The discussion given above which presents and illustrates with examples a theoretical method of determining the working pressure for use with pressure air meters should prove of value to manufacturers of equipment and others concerned with the calibration of such instruments. The method requires careful measurement of the dimensions of the apparatus, determination of certain volumes and selection of certain other approximation values, in order that data may be computed which may be used to set up calibration curves. Once this is done, the curves may be used during the life of the instrument provided its physical characteristics which would affect the calibration do not change and provided the pressure gage is accurate.

From the viewpoint of the user of such equipment the author has preferred the practical method of calibration set up by Mr. C. A. Menzel using the calibration cup. This method of calibration can be performed frequently, if necessary, in the field with only a small expenditure of time and is a complete check on the performance of the instrument as well as a means of correcting for variations in barometric pressure.

As pointed out in the last paragraph of the above discussion, it is important in the use of the proposed theoretical method of calibration that the pressure gage be of the precision type and that it be accurate over its entire range. It is also important that the gage retain its accuracy during the period that the calibration chart is in use for determining working pressures. If the gage should be permanently thrown out of adjustment it must be checked by a mercury manometer and repaired or a correction factor applied to the calibration curve. If the calibration of a pressure gage should be permanently changed on an instrument with which the calibration cup method is being used for calibration, the gage may still be used by determining by test the pressure which should be used as indicated by the damaged gage. This pressure reading on the gage may be used so long as the gage does not change again even though it does not indicate the true pressure. This will prove to be of advantage in the field and in laboratories where it is not convenient to check and maintain pressure gage accuracy.

It is believed that both methods of calibration may be used providing, of course, that proper precautions are taken as indicated above. For field use the calibration cup method will probably prove more practical than the mercury manometer for checking the pressure test equipment.

The Nonevaporable Water Content of Hardened Portland-Cement Paste—Its Significance for Concrete Research and Its Method of Determination

By Treval C. Powers[1]

SYNOPSIS

The physical composition of hardened portland-cement paste can be computed from empirical relationships involving the original water content of the fresh paste, the nonevaporable water content of the hardened paste at the existing stage of hydration, and the nonevaporable water content when the cement is completely hydrated. The relationships between physical composition and strength, frost resistance, and other factors are discussed with reference to research procedures. Experimental methods for measuring the nonevaporable water content and other qualities of the paste are described.

THE object of this paper is to bring together some recently established empirical relationships involving a measure of the extent of hydration of portland cement. With this new knowledge at hand, the volume composition of hardened cement paste can be expressed in a manner somewhat analogous to absolute-volume-composition data on fresh concrete. Concrete can then be studied in terms of the physical composition of the hardened paste.

The relationships to be discussed here involve quantities that can be measured in the usual concrete laboratory without the aid of special equipment. All that is required for most purposes is an accurate measurement of the original net water-cement ratio and a quantity called the nonevaporable water. The determination of the nonevaporable water requires only simple measurements of ignition loss, supplemented in some cases by an analysis for CaO.

The nonevaporable water is the amount retained by a sample after it has been subjected to a drying procedure intended to remove all the free water; it is essentially the same as that which others have called chemically combined or fixed water. However, as has been brought out by Lea (1),[2] no simple drying procedure is capable of separating chemically combined from physically adsorbed water; hence, the water retained by a sample under certain conditions of drying to be described is here called simply nonevaporable, meaning that it is not evaporable under the conditions of drying specified.

The amount of nonevaporable water that may be found in hardened cement paste depends on the conditions under which hydration has taken place, particularly on the time during which an ample supply of water has been available, and to some extent on the chemical composition of the cement. From experiments made recently it has been learned that a portland cement can be hydrated completely by grinding it for four or five days in water at room temperature. The maximum amount of nonevaporable water for a typical, completely hydrated type I cement is about 26 g. per 100 g. of cement. For pastes hardening under the usual laboratory conditions (water or fog storage) a state of complete hydration is approached very slowly and may never be reached unless the cement is extraordinarily free from particles having diameters greater than about 50 μ. With any given cement, the lower the original water-cement ratio, the lower the average rate of approach toward the maximum degree of hydration.

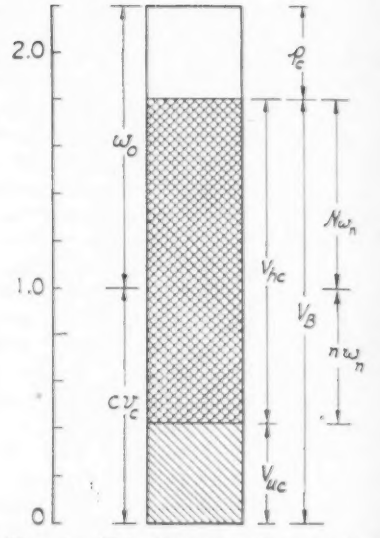


Fig. 1.—This Diagram Represents a Paste Made of Cement No. 15365 Having an Original Water-Cement Ratio of 1.2 in Absolute-Volume Units and at a Stage of Hydration Where w_n/c = 0.169 Corresponding to About 65 per cent of Complete Hydration.

COMPOSITION OF CEMENT PASTE

Figure 1 represents the physical composition of a certain cement paste containing 1 cu. cm. of cement and having a water-cement ratio of 1.2 in absolute volume units (0.38 by weight). The composition of the fresh paste is indicated at the left side of the diagram, where:

w_o = volume of original mixing water, corrected for bleeding, in cubic centimeters, and

cv_c = volume of original cement, c being the weight in grams, and v_c the specific volume in cubic centimeters per gram.

Pastes prepared in the ordinary manner contain bubbles of air. However, the space occupied by entrained air can be disregarded in these considerations. Such voids influence the strength and other properties of the hardened paste, but so far as we know they do not influence the hydration of the cement. We are primarily concerned with the space in the paste that is available for the formation of gel and other

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 1916 Race St., Philadelphia 3, Pa.

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[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

hydration products. This is the water-filled space only.

The symbols on the right-hand side of Fig. 1 represent the physical components of the paste. The corresponding areas represent the amounts of each component that are present at a particular stage of hydration. Thus,

V_{uc} = volume of unreacted cement in cubic centimeters, represented by the cross-hatched area,

V_{hc} = volume of the hydrated cement in cubic centimeters, represented by the double cross-hatched area, and

p_c = volume of capillary pores in cubic centimeters. This is a residue of the originally water-filled space. It is represented by the open area at the top.

The capillary pores are believed to exist as an interconnected system of submicroscopic channels in the hardened paste. These pores are mainly responsible for the permeability of the paste and its vulnerability to frost action.

Besides the capillary pores, the hardened paste contains other ultrafine pores. These pores are a characteristic feature of the hydrated cement, their quantity always being directly proportional to the amount of hydrated cement in the paste. Hence, they are called *gel pores* and are considered to be a constituent of the hydrated cement.

The total volume of solids in the hardened paste is the sum of the unreacted cement and the hydrated cement. In Fig. 1 it is designated as V_B, the "bulk volume of the solid phase."

Empirical relationships will now be given whereby the amounts of each of the components described above can be ascertained. These relationships will be given in terms of the amounts of nonevaporable water in the paste since the nonevaporable water is a readily measurable quantity. It may be noted that the nonevaporable water is not represented directly in Fig. 1; it is not equal to any of the components. It is proportional to the amount of hydrated cement.

Bulk Volume of the Solid Phase, V_B:

The total bulk volume of the solids in a sample of paste at any stage of hydration is given by Eq. 1:[3]

$$V_B = cv_c + 0.75(1 + 4k)w_n \quad (1)$$

where:

w_n = nonevaporable water in the sample, in grams, and

k = a constant characteristic of the particular cement used.

The nonevaporable water is the water retained by the hardened paste when it is dried in a vacuum desiccator at 23 C. over magnesium perchlorate minus the original ignition loss of the cement. More accurately stated, the drying agent is the system[4]

$$Mg(ClO_4)_2 \cdot 2H_2O + Mg(ClO_4)_2 \cdot 3(\text{or } 4)H_2O_3$$

The constant k can be evaluated from the computed compound composition of the cement by means of Eq. 2 (2, p. 486):

$$k = 0.23(C_3S) + 0.32(C_2S) + 0.32(C_3A) + 0.37(C_4AF) \quad (2)$$

where each symbol in parentheses indicates the computed weight fraction of the compound, per gram of cement.[5] The k represents a ratio, specifically,

$$k = V_m/w_n \quad (3)$$

where:

V_m = theoretically the number of grams of water required to cover the surface of the hydrated cement in the sample (the "internal surface") with a layer averaging one molecule deep.

Theoretically, 3570 V_m is equal to the surface area of the hydrated cement in square meters (2, p. 489, Eq. 6): Hence,

$$3570kw_n = \Sigma \quad (4)$$

where:

Σ = surface area of the hydrated cement in square meters.

All equations involving k are valid only for pastes that have been cured at about 73 F.

In Fig. 1, the relationships between the amounts of the different components are such as to conform to the characteristics of a particular type I cement, No. 15365. For this cement, $k = 0.254$ and $v_c = 0.319$. Hence, from Eq. 1 the bulk volume of the solids in the paste per cubic centimeter of cement becomes

$$\frac{V_B}{cv_c} = 1 + 4.73\,\frac{w_n}{c} \quad (5)$$

Volume of Unreacted Cement, V_{uc}:

For each increment of w_n, a corresponding volume of cement becomes hydrated. If n = the volume in cubic centimeters of original cement that becomes hydrated when w_n increases by 1 g., the amount of cement that remains unreacted at a given stage of hydration may be stated in terms of w_n as follows (2, p. 707, Eq. 18):

$$V_{uc} = cv_c - nw_n \quad (6)$$

As will be seen further on, n is a constant for a given cement that can be utilized advantageously; hence, it should be evaluated. Note that when all the cement is hydrated, $V_{uc} = 0$, and Eq. 6 gives

$$n = \frac{v_c}{(w_n/c)^\circ} \quad (7)$$

where:

v_c = specific volume of the original cement, in cubic centimeters per gram, and

$(w_n/c)^\circ$ = the weight-ratio of nonevaporable water to cement when all the cement is hydrated.

For cement No. 15365 $(w_n/c)^\circ$ is about 0.26 and $v_c = 0.319$. Thus,

$$n = \frac{0.319}{0.26} = 1.22 \text{ cu. cm. per g.}$$

That is, in this case, a 1-g. increase in nonevaporable water signifies the hydration of 1.22 cu. cm. of cement.

For some purposes, as in constructing Fig. 1, it is convenient to use the following expression obtained from Eqs. 6 and 7:

$$\frac{V_{uc}}{cv_c} = 1 - \frac{w_n}{w_n^\circ} \quad (8)$$

the quantity w_n/w_n° being the weight ratio of the existing quantity of nonevaporable water to the quantity when all the cement is hydrated.

Volume of Hydrated Cement, V_{hc}:

The volume of hydrated cement may be expressed as:

$$V_{hc} = V_B - V_{uc} \quad (9)$$

or, by Eqs. 1 and 6, and letting

$$0.75(1 + 4k) = N, \quad (10)$$

[3] In a previous publication (Ref. 2, p. 688, the constant in this equation has been given as 0.86. Continued use has shown that this figure is too high; it consistently gives negative porosity when applied to rich and well cured pastes. The figure 0.75 used above is that required to avoid such a result. The reason why the earlier figure is incorrect has not yet been discovered, but the fact that it was derived from data on pastes that had been dried and resaturated is probably involved.

[4] The composition of the higher hydrate is uncertain. The experiment is so conducted that the water content of the desiccant never exceeds 3 mols.

[5] C_3S = $3CaO \cdot SiO_2$. C_2S = $2CaO \cdot SiO_2$. C_3A = $3CaO \cdot Al_2O_3$. C_4AF = $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$.

$$V_{hc} = (N + n)w_n \quad \ldots\ldots (11)$$

For cement No. 15365, $n = 1.22$ and $k = 0.254$. This gives, from Eq. 11, $N = 1.51$. Thus,

$$V_{hc} = 2.73w_n$$

or:

$$\frac{V_{hc}}{cv_c} = \frac{2.73}{0.319}\frac{w_n}{c} = 8.56\frac{w_n}{c} \quad \ldots (12)$$

Volume of Gel Pores, p_g:

As mentioned before, the hydrated cement contains a characteristic amount of gel pores. The amount may be obtained in terms of w_n from the equation (2, p. 976, Eq. 9):

$$p_g = 3.6kw_n \quad \ldots\ldots (13)$$

or

$$\frac{p_g}{cv_c} = 3.6\frac{k}{v_c}\cdot\frac{w_n}{c} \quad \ldots\ldots (14)$$

where:

p_g = volume of gel pores in the sample, in cubic centimeters, or the volume of "gel water" if the paste is saturated, and

k = Eq. 2.

For cement No. 15365,

$$\frac{p_g}{cv_c} = \frac{3.6 \times 0.254}{0.319}\cdot\frac{w_n}{c} = 2.87\frac{w_n}{c} \quad \ldots (15)$$

Volume of Capillary Pores, p_c:

The volume of the capillary pores in the sample is given by the equation

$$p_c = w_o - Nw_n \quad \text{(see Eq. 10 and Fig. 1)} \quad \ldots\ldots (16)$$

or

$$\frac{p_c}{cv_c} = \frac{w_o}{cv_c} - \frac{N}{v_c}\cdot\frac{w_n}{c} \quad \ldots\ldots (17)$$

For cement No. 15365, this becomes

$$\frac{p_c}{cv_c} = \frac{w_o}{cv_c} - \frac{1.51}{0.319}\cdot\frac{w_n}{c}$$

$$= \frac{w_o}{cv_c} - 4.73\frac{w_n}{c} \quad \ldots\ldots (18)$$

Freezable Water, w_f:

When a hardened paste is saturated with water, the capillary water can be frozen if the temperature is low enough. The amount that will freeze is a function of the degree of temperature below the normal freezing point (2, p. 991). The amount that is freezable at a given temperature may be calculated in terms of w_n, as follows:

$$(w_f)_t = w_o - (0.50 + uk)w_n \quad \ldots (19)$$

when:

$(w_f)_t$ = weight of water in a saturated sample that can remain frozen at a given temperature, t,

u = a constant determined by the amount of water that remains unfrozen at the given temperature, and

k = Eq. 2.

Values of u have been determined experimentally and may be taken as follows:

Temperature		u
Deg. Cent.	Deg. Fahr.	
−12	+10.4	4.0
−20	−4.0	3.7
−30	−22.0	3.2

Hence, for cement No. 15365, Eq. 19 becomes

$$(w_f)_{-12\ C.} = w_o - 1.51w_n \quad \ldots (20)$$

$$(w_f)_{-20\ C.} = w_o - 1.44w_n \quad \ldots (21)$$

$$(w_f)_{-30\ C.} = w_o - 1.31w_n \quad \ldots (22)$$

Surface Area of Hydrated Cement, S:

The area of the hydrated cement, or a factor proportional to it, can be computed from w_n.

Let Σ = surface area of the sample, in square meters, and S = specific surface of the hydrated cement, in square meters per cubic centimeter. Then,

$$S = \frac{\Sigma}{V_{hc}}$$

or, by Eq. 11,

$$S = \frac{\Sigma}{(N + n)w_n} \quad \ldots\ldots (23)$$

Since, by Eq. 4, $\Sigma = 3570kw_n$,

$S = 3570\frac{k}{N + n}$, in square meters per cubic centimeter of hydrated cement. $\ldots\ldots (24)$

The constant 3570 is theoretical and need not necessarily be used. For some purposes, the relative surface can be represented by the factor $k/(N + n)$.

Influence of Original Water-Cement Ratio and Stage of Hydration on the Physical Composition of the Hardened Paste

The significance of some of the relationships given in the preceding section can be better grasped by studying Fig. 2.[6] This is made up of four groups of diagrams of the kind used in Fig. 1. Figure 2 (*a*) represents a series of fresh pastes ranging in original water-cement ratio from zero to 3.0 in absolute volume units.

[6] A different graphical representation of these relationships has previously been presented in another paper (2, p. 708). These earlier graphs were based on fractional parts of a unit volume of paste and thus encompassed every possible ratio of water to cement. The graphs used in the present paper seem somewhat easier to understand. They are fundamentally the same as those used by F. R. McMillan in his "Basic Principles of Concrete Making," McGraw-Hill Book Co., New York, N. Y. (1929).

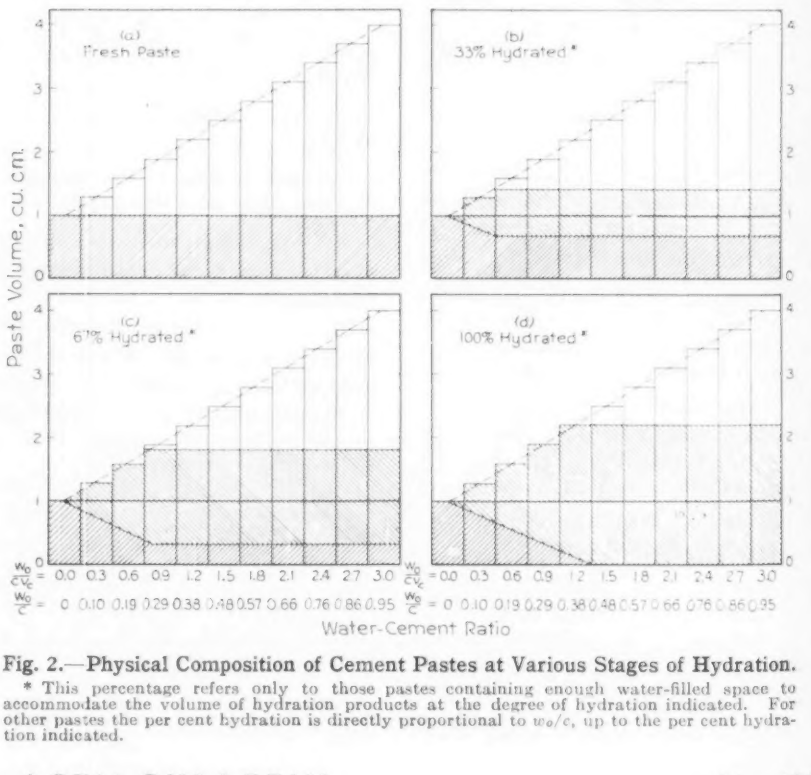

Fig. 2.—Physical Composition of Cement Pastes at Various Stages of Hydration.

* This percentage refers only to those pastes containing enough water-filled space to accommodate the volume of hydration products at the degree of hydration indicated. For other pastes the per cent hydration is directly proportional to w_o/c, up to the per cent hydration indicated.

This group of diagrams shows the different amounts of paste that are obtained from 1 cu. cm. of cement when different water-cement ratios are used.

Figures 2 (*b*), (*c*), and (*d*) represent the same series of pastes after 33, 67, and 100 per cent of the cement has become hydrated, respectively. Like Fig. 1, these are based on the characteristics of cement No. 15365. *It must be emphasized that the diagrams in any one set cannot represent pastes of equal age.* In general, the lower w_o/c, the lower the average rate of hydration and, hence, the older the paste at a given stage of hydration.

The feature of these diagrams to be noted especially is that at any given stage of hydration, the capillary pores do not appear when the water content, w_o, falls below a certain value. At this particular value, hydrated cement has filled all the originally water-filled space, and the only evaporable water present is the gel water. That is, the capillary porosity is zero when the increase in volume due to hydration equals the original water content, or, in terms of the symbols already used, p_c = zero when $Nw_n/c = w_o/c$.

Since for cement No. 15365, N = 1.51 and $(w_n/c)^\circ = 0.26$ (the non-evaporable water at complete hydration), when 33 per cent of the cement is hydrated, $w_n/c = 0.33 \times 0.26 = 0.086$, and similarly for 67 per cent, $w_n/c = 0.174$. Hence, when 33 per cent of the cement is hydrated, p_c = zero when $w_o/c = 0.086 \times 1.51 = 0.130$; when 67 per cent is hydrated, p_c = zero when $w_o/c = 0.174 \times 1.51 = 0.261$; when 100 per cent is hydrated p_c = zero when $w_o/c = 0.26 \times 1.51 = 0.392$.

These figures show that under circumstances where curing is continuous, as, for example, a pavement slab resting on moist soil in a humid region, and if the cement is capable of complete hydration (see below), capillary pores should eventually disappear if the original water-cement ratio is not above 0.39 by weight (4.4 gal. per sack).

It will be noted also that when the original volume of water is insufficient to accommodate all the solids that can be derived from the amount of anhydrous cement originally present, some of the cement must remain unreacted. In general, we may conclude that hydration must cease when $Nw_n = w_o$, or when all the cement is hydrated, that is, when $V_{uc} = 0$.

Hydration may stop before all the anhydrous cement disappears, even though Nw_n is less than w_o; in fact, it usually does. If the cement contains particles having diameters greater than about 50 μ, the largest particles apparently become surrounded with gel so dense and thick that the rate of hydration of the embedded particles soon becomes negligibly low. It is true also that when water is lost by evaporation, or, under some circumstances, by self-desiccation (2, p. 986; 8) hydration may stop before the limits discussed above have been reached.

When the water-cement ratio is above 0.39 by weight, some amount of capillary pores will always be present, regardless of the stage of hydration. At the ultimate stage of hydration the capillary porosity is directly proportional to the amount of water in excess of about w_o/c = 0.39. (This limiting ratio will differ somewhat among cements of different type or different fineness.) The relationship of capillary porosity to w_o/c at other stages of hydration may easily be seen in Fig. 2.

Suggested Applications

Now that it is possible to estimate the volume composition of hardened cement paste, we may reconsider some of our customary practices in concrete research. It is hoped that these considerations will suggest new approaches in various phases of laboratory investigations.

Compressive Strength:

Although compressive strength is not at present a matter of prime concern in concrete research, it is worth while to discuss it because so much of our thinking about concrete stems from the early studies of strength. In particular, it is of interest to reconsider the so-called water-cement ratio law.

In 1897 R. Feret (3) wrote as follows:

"After experiments made on a very great number of mortars, we have established the following law: For all series of plastic mortars made with the same cement and inert sand the compressive strength after the same period of storage under identical conditions is a unique function of the ratio[7]

$$\frac{c}{w+v} \text{ or } \frac{c}{1-(c+s)}$$

whatever the nature and size of the sand and the proportions of the elements cement, inert sand and water of which each is composed."

In 1918, Duff A. Abrams (4) published test results from which he deduced the following conclusion, practically identical with that of Feret as applied to plastic mixes:

"With given concrete materials and conditions of test the quantity of mixing water used determines the strength of the concrete as long as the mix is of workable plasticity."

A recent statement reads as follows (5):

"For plastic mixtures, using sound aggregates, the strength and other desirable properties of concrete under given job conditions are governed by the net quantity of mixing water used per sack of portland cement."

After Abrams' paper was published, the generalization given in the quoted statements played a very important role in the development of concrete technology; deserved credit has been given to those who observed and reported this useful relationship. It has also formed the basis of much research; that is, many comparisons at a given test age have been made on the basis of equality of water-cement ratio. Indeed, many who are engaged in research, including the present author, have regarded this empirical relationship as a fundamental law.

Accurately speaking, we cannot say that the strength of mortar or concrete is determined by the quantity of water or even by the quantity per unit of cement. When we make such statements we are leaving unsaid many implied qualifications that must be taken into account if the statement is correctly understood. Statements of this kind should, of course, not be regarded as statements of law.

The strength of concrete *of a given water-cement ratio* depends upon various factors, the most important of which are the following: the amount of cement that has become hydrated up to the time of ob-

[7] c = volume of cement. w = volume of water. v = volume of air-voids. s = volume of sand.

servation; the chemical and physical characteristics of the cement; the temperature at which the hydration of the cement takes place; the air content of the concrete; the relative amount of fissures under the aggregate particles, a bleeding effect (10). We are therefore hardly justified in employing the water-cement ratio "law" except as a practical device for use in designing concrete mixes. For research work it is worth while to seek a relationship that *explicitly* evaluates at least some of the factors enumerated above.

By inspection of Fig. 2 we may surmise, as others have done before (11), that strength is some function of the concentration of the hydrated cement in the space available to it; or since hydrated cement is mostly gel, we may say it is some function of the gel-space ratio. This may be expressed as follows:[8]

$$f_c = \phi_1 \left[\frac{V_{hc}}{V_{hc} + p_c} \right] \quad \ldots\ldots (25)$$

where:

f_c = compressive strength,
V_{hc} = volume of hydrated cement, and
p_c = capillary pores.

Since

$$V_{hc} = (N + n)w_n \quad \text{(Eq. 11)}$$

and

$$p_c = w_o - Nw_n \quad \text{(Eq. 16)}$$

$$f_c = \phi_1 \left[\frac{(N + n)w_n}{nw_n + w_o} \right] \quad \ldots\ldots (26)$$

Thus, for cement No. 15365 (using constants already given),

$$f_c = \phi_1 \left[\frac{2.73w_n}{1.22w_n + w_o} \right] \quad \ldots\ldots (27)$$

Similarly, for another cement, No. 14930J, for which $(w_n/c)^\circ = 0.225$ estimated, $k = 0.304$, and $v_c = 0.311$, we have

$$n = \frac{0.311}{0.225} = 1.38 \quad \text{(by Eq. 7)}$$

$$N = 0.75\ (1 + 4 \times 0.304) = 1.66 \quad \text{(by Eq. 10)}$$

Hence,

$$N + n = 3.04$$

and

$$f_c = \phi_1 \left[\frac{3.04w_n}{1.38w_n + w_o} \right] \quad \ldots\ldots (28)$$

[8] In the earlier paper (2) Part 6, a different expression is called the gel-space ratio. The present treatment is intended to be a refinement of the original idea.

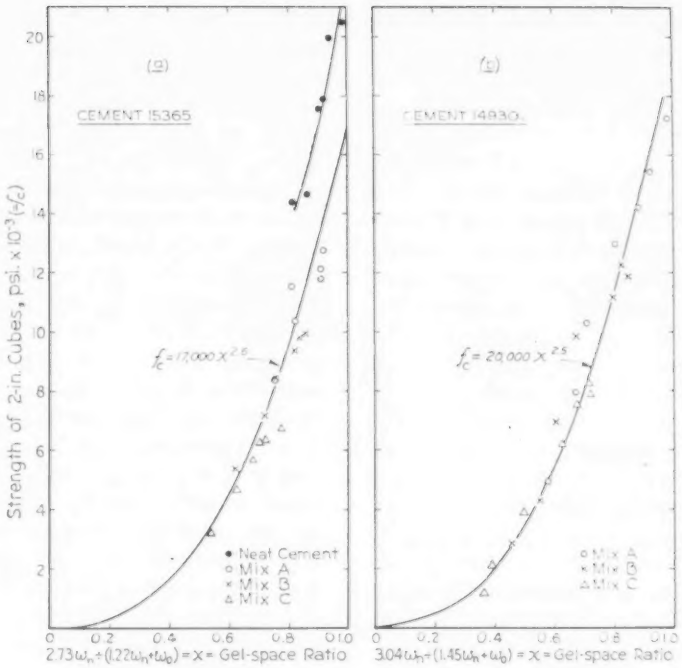

Fig. 3.—Relationship Between Compressive Strength and the Gel-Space Ratio.

When these ratios were plotted against corresponding strengths, the results were as shown in Fig. 3. The points plotted represent different mixes, and each mix is represented at six or seven different ages ranging from 7 days to 6 months or 1 yr. Plotted on the basis of the original cement-water ratio, or cement-space ratio, the points for different ages would have fallen on different curves.

The data for cement No. 15365, except those representing neat cement, can be represented by the expression

$$f_c = 13{,}000 \left[\frac{2.73w_n}{1.22w_n + w_o} \right]^3 \quad \ldots (29)$$

Those for cement No. 14930J, which did not include neat cement, can be represented by

$$f_c = 16{,}000 \left[\frac{3.04w_n}{1.45w_n + w_o} \right]^{2.4} \quad \ldots (30)$$

Because of Abrams' work it is of interest to examine the reciprocal of Eq. 26, that is,

$$f_c = \phi_2 \left[\frac{nw_n + w_o}{(N + n)w_n} \right]$$

$$= \phi_2 \left[\frac{n}{N + n} + \frac{w_o}{(N + n)w_n} \right]$$

or, since n and N are constant for a given cement,

$$f_c = \phi_3 \left[\frac{w_o}{w_n} \right] \quad \ldots\ldots (31)$$

This function is the same as that used by Abrams except that w_n, a figure proportional to the amount of *hydrated* cement, is used instead of c, the amount of original cement. Therefore, we may plot log f_c *versus* w_o/w_n, obtaining a graph analogous to that of Abrams.

The results are shown in Fig. 4. Both sets of mortar data conform reasonably well to the relationship

$$f_c = \frac{40{,}000}{B^{w_o/w_n}} \quad \ldots\ldots (32)$$

where B is a constant characteristic of the cement. Perhaps the correlation appears to be better than when plotting on the basis of Eq. 27, but this appearance is due to the relative smallness of the scale of ordinates.

It should be noted that in Fig. 4 (*b*), the points representing neat cement do not conform to the relationship indicated by the mortar data. This is one of the various indications that these relationships, though more general than the older ones, are nevertheless empirical and do not include all the variables influencing strength. In Fig. 3 (*a*), it is very clear that neat cement is stronger than mortar, even when the gel-space ratios are equal.[9] The ag-

[9] The air contents in the various specimens, though neglected here, did not differ enough to change the conclusions indicated by the data as used here.

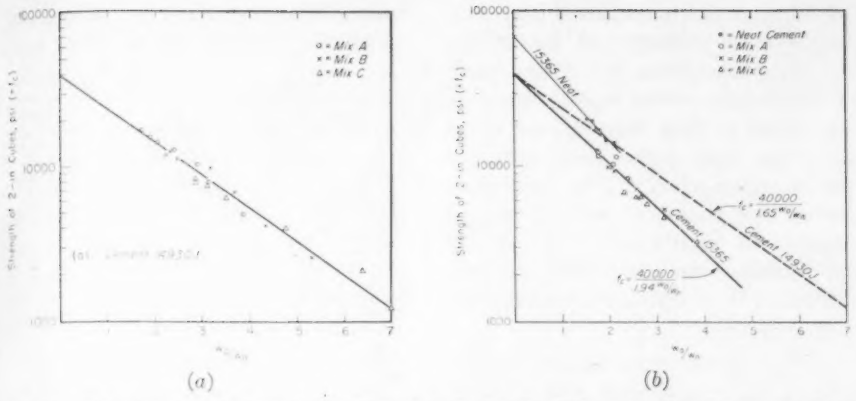

Fig. 4.—Relationship Between Compressive Strength and w_o/w_n for Cements Nos. 14930J and 15365.

gregate is obviously a weakening factor, at least within the range of water-cement ratios where comparisons can be made. It should be noted that at least within this range strength is apparently a function of the paste-aggregate ratio as well as of the gel-space ratio. When the gel-space ratio is unity, strength is solely a function of the paste-aggregate ratio.

It is significant also that the strengths obtained at a given gel-space ratio are distinctly higher for cement No. 14930J than for No. 15365. It has been shown elsewhere (2, p. 852) that the difference is apparently related to the difference in tricalcium aluminate contents (6 and 13 per cent, respectively); the higher the tricalcium aluminate content the lower the strength at a given gel-space ratio. Several cements all having tricalcium aluminate contents below 8 per cent conformed to the same relationship; presumably that relationship would hold for all such cements, since other features of composition were not alike.

So far as the practical use of concrete in the field is concerned, these considerations may amount to little more than a quibble. It matters little how or why the water-cement ratio or the cement-space ratio is connected with strength and other properties as long as the connection exists and can be utilized. But for those engaged in research this point of view will not suffice. To identify and evaluate the basic factors in concrete technology the variables must be isolated if possible. The data in Fig. 4 (*b*) afford an interesting example. If the two cements represented in Fig. 4 (*b*) were compared on the basis of the usual water-ratio curves at equal ages, say, 7 or 28 days, we could conclude that No. 15365 is the stronger cement. Or, if the curves for various ages were compared, we could include thatNo. 15365 was the stronger at early ages but the weaker at later ages. However, when we compare them at equal stages of hydration, eliminating age as a variable (since age *per se* actually has nothing directly to do with matter), we see that No. 15365 is the weaker cement at all stages of hydration. We may reasonably assume, therefore, that the substance represented by the middle blocks in Figs. 2 (*b*), (*c*), and (*d*) as produced by cement No. 15365 is characteristically weaker than the cementing substance produced by No. 14930J. We are thus placed in a position to distinguish between the effects of differences in the rate of hydration and differences in the strength of the cementing substances produced by the two cements when they react with water.

It seems apparent from the foregoing considerations that studies dealing with strength or other properties that depend on paste porosity should be based on quantitative knowledge of paste porosity, or on related functions such as the gel-space ratio, as well as on the factors usually considered. Specifically, the suggestion is this: When studying cement characteristics, curing procedures, etc., in relation to strength, the strength of the hydrated cement and the rate of hydration should be considered separately. This can be done with the aid of the relationships summarized in this paper.

Frost Resistance:

One of the principal factors influencing the degree of frost resistance of concrete is the volume of the pores in the paste capable of holding freezable water. In this case the advantage of knowing w_n and the other factors used in computing paste composition is more obvious than it was in connection with strength.

An important implication of Eq. 19 should be noted. This is that the amount of freezable water becomes zero when the two terms of the right-hand side of the equation are equal. Thus, if nonevaporable water content is made high enough by prolonged curing, and choice of cement content, and if the original water content is kept low enough, concrete can be made incapable of containing freezable water. For most purposes, the freezable water may be considered identical with the capillary water; therefore, the conditions controlling the capacity for freezable water may readily be learned by studying Fig. 2.

Other Applications:

Research on various properties of concrete depending on the properties of the paste should be able to employ the relationships summarized in this paper. Consider, for example, the question of volume change due to change in moisture content. In another paper (pp. 582–590) we have advanced the not original hypothesis that shrinking and swelling are due to the change in the moisture content of the cement gel and are independent of the concomitant change in the water content of the capillary pores. Pickett (7) extended the hypothesis by assuming that "the magnitude of shrinking or swelling tendency depends primarily on the amount of surface formed during hydration." Any studies that might be undertaken to test this hypothesis involve the evaluation of the specific surface of the hydrated cement. This can be done through Eq. 24:

$$S = 3570 \frac{k}{N + n}$$

For example, we may compare the pastes made of the cements discussed above, having the following characteristics:

Cement	k	N	n	$N+n$	$\frac{k}{N+n}$
No. 15365	0.254	1.51	1.22	2.73	0.093
No. 14930J	0.304	1.66	1.38	3.04	0.100

Substituting these values in the above equation we find:

For 15365,

S = 332 sq. meters per cu. cm. of hydrated cement

and for 14930J,

S = 357 sq. meters per cu. cm. of hydrated cement

Since the constant 3570 is theoretical, it may be dropped when studying the relative surface areas of different materials.

It is suggested that $k/(N + n)$, evaluated by suitable laboratory data, should be useful in studying stress-strain relationships (plastic-flow; creep under stress) as well as shrinkage. In fact, $k/(N + n)$ should be useful in studying any property that may be dependent on the specific surface of the hydration products.

The indications of data now available are that for pastes cured at 70 to 75 F., cements of different types show similar surface areas per unit volume of hydrated cement. But the specific surface of any given hydrated cement should vary with the temperature of curing, and variations in temperature might influence different types of cement to different degrees. Therefore, S should be of particular interest when studying the influence of curing temperature on shrinkage or plastic flow.

When temperature is a variable, k cannot be evaluated from Eq. 2; it must be determined by direct measurements, using special apparatus not generally found in concrete laboratories. A description of apparatus and procedures for evaluating k is beyond the scope of this paper; the Powers and Brownyard paper (2) should be consulted if such experiments are undertaken.

Laboratory Methods

Nonevaporable Water:

The method of estimating nonevaporable water described here is not the only method that has been or might be used. However, we must point out with special emphasis that if any other procedure is followed, the results obtained may not properly be substituted for w_n in the equations given in the first part of this paper. The reason for this limitation is that the various relationships that have been worked out in terms of w_n are entirely empirical and therefore cannot be extended to conditions that differ very much from the conditions under which the empirical relationships were established.

Although the method for determining nonevaporable water is a comparatively simple laboratory operation, its scope of application is probably restricted to specimens prepared in the laboratory. That is, the method probably will not be very reliable as a means of diagnosing samples obtained from the field, at least not until more experience with the method has been acquired. Moreover, its usefulness in the laboratory may be limited, especially with respect to the types of aggregate that may be used in concrete specimens. For the present, it appears of greatest value in those studies where the properties of the paste are under study and in which the aggregate most convenient to handle may be used. Indeed, many such studies might properly be restricted to studies of neat cement.

Determining w_n on Neat Pastes.—The determination of nonevaporable water requires the following steps:

(1) Preparing a sample,
(2) Removing the evaporable water,
(3) Determining the loss on ignition, and
(4) Calculating the nonevaporable water content.

Procedure.—Pass the original specimen rapidly through a crusher. Then sieve the pulverized material, using a No. 35 and a No. 100 sieve. Save the material caught between the sieves (Note 1).

Note 1.—This is the particle size recommended but other sizes may be used. The finest flour in the pulverized material is representative, but it would have to be handled with great care to avoid losses and carbonation during subsequent operations. Larger particles would be satisfactory, but the time required for drying them is unnecessarily long.

Dry about 5 g. of the sized granular sample to constant weight in a vacuum desiccator charged with magnesium perchlorate dihydrate (Note 2).

Note 2.—The dihydrate of magnesium perchlorate must be prepared from the commercial drying agents, sold as the anhydrous salt. Special precautions must be taken to be sure that the desiccating agent has the desired composition. Commercial products now available, though labeled "anhydrous," have been found often to contain some water; hence, before the product is used its water content must be removed or determined. The water can be removed by heating the material in a vacuum at 300 C.

When the moisture content of the commercial material has been determined or removed, a quantity of the desiccant is then mixed in a closed vessel with exactly enough water to increase the water content to 2.1 mols of water per mol of the anhydrous salt. The desiccators are then charged from this stock. When the water content of a used desiccating agent approaches 3 mols, it is discarded.

When a considerable number of samples are being handled on a routine basis, it is convenient to use two or three desiccators, the first containing previously used desiccant and the last freshly prepared desiccant.

Using a 1- to 3-g. portion of the dry sample, measure the loss on ignition at 1000 C., heating the sample for 20 min.

As a separate operation, determine the loss on ignition of the original cement by the usual procedure.

Calculating w_n.—The nonevaporable water is defined as the increase in loss on ignition due to hydration, in grams per gram of original cement.

Let

w_n/c = ratio of nonevaporable water to cement in grams per gram of original cement,
W_1 = weight of dry sample in grams,
W_2 = weight of ignited sample in grams, and
L = ignition loss of original cement in grams per gram of original cement.

Then[10]

$$\frac{w_n}{c} = \frac{W_1}{W_2}(1 - L) - 1 \quad \ldots (33)$$

Mortar or Concrete Containing No Calcareous Aggregate:

In the Portland Cement Association laboratory, the determination of nonevaporable water in samples containing aggregate has been restricted to aggregate that is free from calcareous minerals or other minerals that dissolve in acid or decompose in the ignition test. Specifically, it has been confined to plastic mortars made of mixes con-

[10] Derivation:
By definition, $W_1 = c + w_n$.
Also W_2 = weight of ignited cement = $c(1 - L)$
Hence $\frac{c + w_n}{c(1 - L)} = \frac{W_1}{W_2}$
or
$$1 + \frac{w_n}{c} = \frac{W_1}{W_2}(1 - L)$$
$$\frac{w_n}{c} = \frac{W_1}{W_2}(1 - L) - 1$$

taining Ottawa sand (nearly pure silica) and, in the leaner mixes, pulverized silica.

Procedure.—The procedure for material of the kind just described is the same as for neat cement except that the sample should be of such size as to contain about 5 g. of the original cement, and with the further exception that CaO content of the sample must be determined.

In computing w_n/c when aggregate is present, the following formula may be used:

$$\frac{w_n}{c} = \left\{\frac{W_1}{W_2}[(1 - L) - 1]\right\} \times \left[\frac{\text{CaO, g. per g. of original cement}}{\text{CaO, g. per g. of ignited sample}}\right] \quad (34)$$

Other Samples:

Samples containing other types of aggregates possibly can be used. The difficulties to be expected are so various that it would be futile to attempt to anticipate and solve them here. However, Verbeck and Klieger (9) have used a method that should be mentioned. They studied concrete specimens containing limestone. Desiring data on the nonevaporable water contents of the specimens at certain ages, they prepared neat cement specimens having the same water-cement ratios as the corresponding concrete specimens. The neat specimens were cured under the same conditions as the concrete and the nonevaporable water contents of the neat specimens were determined at appropriate ages.

This procedure involves the assumption that neat cement hydrates at the same rate as the cement in the concrete specimens. This is a reasonable assumption, provided that the water-cement ratios are equal. If the water-cement ratio of the neat cement is less than that of the concrete, the rate of hydration of the neat cement will be lower than that of the cement in the concrete except perhaps for water-cement ratios above 0.6 by weight.

Determining w_o:

To estimate the capillary porosity of a sample, it is necessary not only to determine w_n and k but also the original net water content w_o. As mentioned before, the quantity w_o is the volume of water-filled space in which the hydration products will be deposited. This excludes water lost by bleeding and water in the pores of the aggregate particles. The required correction for bleeding is very simple:

$$\frac{w_o}{c} = \frac{w}{c} - \frac{w_B}{c} \quad (35)$$

where:

w = total amount of mixing water,
w_B = amount of water lost by bleeding, and
w_o = net water content after bleeding.

Because the necessary corrections to the initial water content can be arrived at equally well in various ways, no detailed procedure will be given here. Whatever the chosen procedure, it should meet the following requirements:

1. The amount of water lost by bleeding should be measured directly on each specimen.
2. If aggregate is present it must not absorb water during the bleeding period, that is, it must be nonabsorptive or presaturated.

Evaluation of n of Eq. 7:

The evaluation of n—the volume of cement that becomes hydrated per gram increase in nonevaporable water—requires bringing a sample of the cement to the completely hydrated stage. Since the method to be described here has only recently been developed, it is offered tentatively. Probably modifications will result from more extensive experience with the method.

In the initial experiments, about 600 g. of cement were placed in a laboratory jar mill with two liters of water and the mill was rotated continuously, the mill being kept at proper temperature with a water bath. At intervals the nonevaporable water was determined on samples. This procedure was continued until w_n/c ceased to increase.

It was necessary to analyze each sample for iron and to correct the ignition loss for the gain due to oxidation of the metallic iron picked up by the sample during the grinding. Possibly a correction should be made for an increase in the insoluble residue due to wear of the ceramic jar, though that was not done in these experiments.

Currently, the grinding is being done in specially constructed mills made of hardened steel, designed to accommodate about 100 g. of cement.

Nomenclature

B = a constant in Abrams' equation for the water-cement ratio law.
c = weight of cement in grams.
f_c = compressive strength in pounds per square inch. (In this paper all the strength data given are from 2-in. cubes.)
k = a constant characteristic of a particular cement.
k = V_m/w_n.
n = volume (in cubic centimeters) of original cement that becomes hydrated when w_n increases by 1 g.
N = the volume (in cubic centimeters) by which the solid phase (including gel pores) increases when w_n increases by 1 g.
N = $0.75\ (1 + 4k)$.
p_c = volume of capillary pores in cubic centimeters—that is, the part of w_o that has not become filled with hydrated cement.
p_g = volume of gel pores in cubic centimeters.
S = specific surface of hydrated cement in square meters per cubic centimeters.
u = a constant determined by the amount of water that remains *unfrozen* at a given temperature.
V_B = volume of unreacted cement plus hydrated cement plus gel pores. Because this volume includes the gel pores, it is referred to as the "bulk volume of the solid phase" in the paste.
v_c = specific volume of cement in cubic centimeters per gram. This is the reciprocal of density, or of specific gravity if the specific gravity is referred to the density of water at 4 C.
V_{hc} = volume of hydrated cement in cubic centimeters.
V_m = theoretically, the number of grams of water required to cover the surface of the hydrated cement (the "internal surface") with a layer averaging 1 molecule deep.
V_{uc} = volume of unreacted cement in cubic centimeters.
$(w_f)_t$ = weight of freezable water in a saturated sample for a given temperature, t.
w_n = nonevaporable water in grams.
$(w_n/c)^\circ$ = the weight-ratio of nonevaporable water to cement when *all* the cement is hydrated.
w_o = volume of original mixing water, corrected for bleeding, in cubic centimeters.

ϕ_1, ϕ_2 etc., indicate particular functions of the expression in parentheses.

Σ = surface area of the hydrated cement in square meters.

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Building Research Advisory Board Established

THE new Building Research Advisory Board working under the auspices of the National Research Council has been organized as a nonpartisan, fact-finding group for government, private industry, and educational institutions, to help mobilize American research talent on a public service basis to produce facts aimed at providing more and better building construction, including housing for more people at lower cost.

The National Research Council is the operating agency of the National Academy of Sciences, an organization that has made notable contributions to national progress since 1863.

The Board will not directly engage in research activities but will limit itself to presenting facts, based on the best available scientific information, according to Frank B. Jewett of Short Hills, N. J., Chairman of the Building Research Advisory Board. Dr. Jewett, one of the world's senior industrial scientists, considered the task assigned to the Board so important he accepted the chairmanship of the Board after having served for eight years as President of the National Academy of Sciences.

"The Building Research Advisory Board is not constituted to carry on research activities itself," Dr. Jewett said, "but it will stimulate and encourage research at existing facilities of private industry, educational institutions and the government. The Board believes that its maximum service to the nation can best be achieved by giving the widest distribution to well-authenticated facts on controversial subjects. It will leave to others the interpretation as to what courses of action might be justified by these facts."

At its first meeting late in February, the Board acted to procure a permanent full-time director, and accepted from the Federal Housing and Home Finance Agency commission to undertake a study of why modular coordination has not found wider practical use in home construction in spite of its extensive technical development. It agreed that the initial efforts of the permanent Director, when selected, should be on exploring experimentally the best methods for analyzing the research needs of the building construction industry and the extent to which these needs are being adequately investigated at the present time.

In addition to Dr. Jewett whose address as chairman of the Building Research Advisory Board will be the National Research Council, 2101 Constitution Ave., Washington 25, D. C., other members of the Executive Committee are Frederick M. Feiker, Dean, School of Engineering, George Washington University; George M. Hunt, Director, Forests Products Laboratory, U. S. Dept. of Agriculture; C. F. Rassweiler, Vice-President in Charge of Research and Development, Johns-Manville Corp.; W. E. Reynolds, Commissioner, Public Buildings Administration, Federal Works Agency; and Walter A. Taylor, Director, Research and Education, American Institute of Architects.

University of Michigan Summer Session to Emphasize Theory of Elasticity and Structures

THE University of Michigan is offering a series of summer symposiums consisting of a broad program in engineering and applied mechanics, emphasizing each year a different phase of mechanics, although courses are offered in all fields with the cooperation of all departments of the university. This summer the symposium, scheduled for June 20 to August 13, will emphasize the theory of elasticity and structures. Guest professors who will offer advanced courses include Sir R. V. Southwell, formerly Rector of the Imperial College of London, Dr. S. Timoshenko of Stanford University, and Dr. E. Reissner of the Massachusetts Institute of Technology. In addition lectures on specific topics will be given by outstanding engineers and scientists.

Two interesting national meetings will be held at the University of Michigan during the week preceding the symposium, namely, the Summer meeting of the Applied Mechanics Division of The American Society of Mechanical Engineers, and the second Annual Conference on Applied Mathematics sponsored by the American Mathematical Society. The principal papers at these meetings also will relate to the theory of elasticity and structures.

Further information may be obtained by addressing Prof. E. L. Eriksen, Chairman, Department of Engineering Mechanics, University of Michigan, Ann Arbor, Mich.